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STATE OF NEVADA

AGENCY FOR NUCLEAR PROJECTS/ NUCLEAR WASTE PROJECT OFFICE

DOE/NV/10461--T40-Vol.3

DE90 005486

STATE OF NEVADA COMMENTS

ON THE

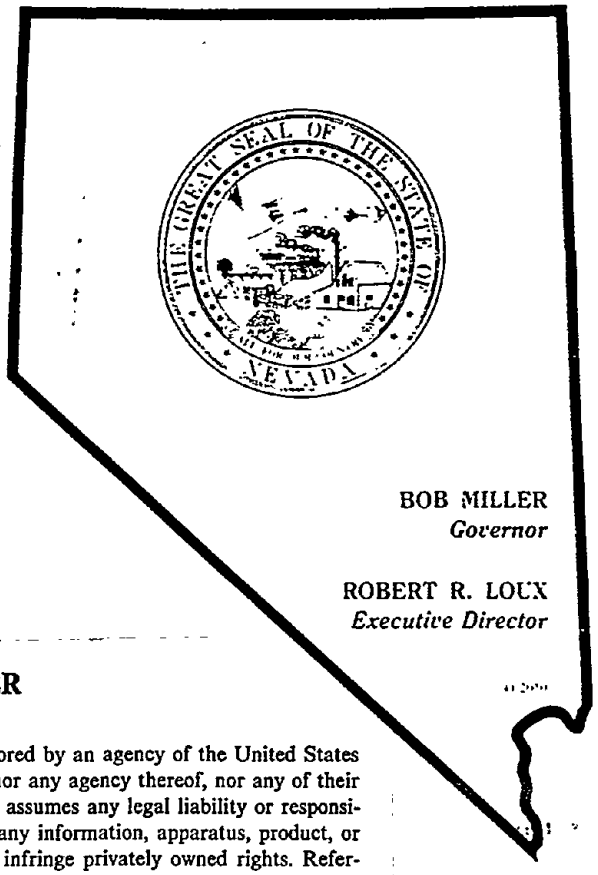
U.S. DEPARTMENT OF ENERGY

SITE CHARACTERIZATION PLAN

YUCCA MOUNTAIN SITE

NEVADA

VOLUME III



BOB MILLER
Governor

ROBERT R. LOUX
Executive Director

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STATE OF NEVADA COMMENTS

ON THE

U.S. DEPARTMENT OF ENERGY

SITE CHARACTERIZATION PLAN

YUCCA MOUNTAIN SITE

NEVADA

VOLUME III

PREPARED BY

NEVADA AGENCY FOR NUCLEAR PROJECTS/
NUCLEAR WASTE PROJECT OFFICE

SEPTEMBER 1989

COMMENTS OF

L. LEHMAN & ASSOCIATES

TECHNICAL REVIEW OF THE

SITE CHARACTERIZATION PLAN

YUCCA MOUNTAIN SITE
NEVADA RESEARCH AND DEVELOPMENT AREA, NEVADA
DEPARTMENT OF ENERGY, DECEMBER 1988

Prepared for

Nevada Nuclear Waste Project Office
Capitol Complex
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June 29, 1989

EXECUTIVE SUMMARY

Yucca Mountain, Nevada has been selected as a potential high-level radioactive waste repository, the Nation's first. The waste would be emplaced about 200 meters above the water table in a volcanic rock called tuff. Because of the highly radiologic character of the waste, it must be isolated from the accessible environment for 10,000 years as defined in 40 CFR Part 191.

To determine if the Yucca Mountain site is a suitable location for permanent geologic disposal of this waste, the Department of Energy (DOE) has proposed a complex plan of testing as outlined in the Site Characterization Plan (SCP). The SCP reviews the available information on the physical, chemical, biological and human systems of the Yucca Mountain area. It then outlines a course of study of these systems, a design of the repository and related engineering structures, and plans for assessing the performance of the repository.

One of the most important systems to understand, yet one of the least understood, is the hydrologic system at Yucca Mountain. The importance of this system is that it probably contains the most likely pathways for radionuclide escape from the repository to the accessible environment. The hydrology of the unsaturated highly-fractured tuffs, in which the proposed repository would be constructed, is poorly understood. This is because very little scientific study of this type of hydrogeologic system had been made prior to the selection of Yucca Mountain as a potential repository.

Our review of the hydrologic and hydrogeologic aspects of the SCP raises many serious concerns regarding both the current uncertainties regarding these systems, and more importantly, the DOE's plans for investigations of the hydrologic and hydrogeologic systems. The major concerns are of: 1) the time limitations for conducting the necessary investigations; 2) the great uncertainty regarding the hydrologic processes, especially fracture flow, in the unsaturated zone; 3) the inadequate consideration of various hydrogeologic and hydrologic factors, including coupled flow processes, recharge and discharge, and perched water zones; 4) the inadequate conceptual and numerical models of the saturated and unsaturated zones, and development of scenarios; 5) the flaws in the design and monitoring of observation wells; 6) the uncertainties in estimating infiltration, ground water travel time, the extent of the disturbed zone, and waste package integrity; and 7) the overall biased approach of the SCP. This report consists of a summary of these concerns, followed by specific comments on portions of Chapters 3 and 8 of the SCP.

APPROACH

Our review concentrated on all of Chapter 3, and major sections of Chapter 8 of the SCP. Familiarization with the relevant publications and research related to the Yucca Mountain area provided a background for the technical review of the SCP.

Many of the comments made on the Consultation Draft-SCP still apply to the SCP. To integrate these comments with the new comments, all of our original comments were reviewed against the applicable sections of the SCP. The comments were either retained as stated, modified if needed, or removed if the section had been changed to adequately address the concern of the original comment. Section 8.3 of the table of contents of the Consultation Draft SCP was then compared with Section 8.3 of the final SCP and changes were noted. Added or modified sections were then reviewed and commented upon where appropriate.

Selected sections of the SCP were reviewed by several individuals and additional comments were prepared. These were then edited, integrated with the original comments, arranged consecutively by page, numbered, and finally reviewed by our QA manager. The individual comments follow the discussion of major comments below, with the Chapter 3 comments preceding those of Chapter 8.

DISCUSSION

The Site Characterization Plan is an immense document that correlates in shear size with both the complexity of the physical systems in the Yucca Mountain region, and the lack of knowledge regarding the geologic, hydrologic, and engineering aspects and processes acting in this setting. To investigate Yucca Mountain and determine if high-level radioactive waste could be safely isolated from the environment there, will require a number of years of investigation and will be extremely costly. Our review points to the conclusion that characterization of the Yucca Mountain site will be very difficult and it appears unreasonable that it will be accomplished by the time slated for the license application.

The geologic setting itself is complicated with heterogeneous volcaniclastic sediments, which are moderately or heavily fractured. Numerous faults exist in the area, with some bisecting the proposed repository site. Although the faults were hypothesized to be old, it appears that some may have been active in the late-Quaternary. Volcanoes in the area originally assumed to be old, also may have been active in the late-Quaternary. Because Yucca Mountain is located in a tectonically active setting,

both tectonic stresses and thermal processes need to be considered in analyzing the behavior of the geologic media and its fluids.

Although the landscape is arid, both winter rains and infrequent summer thunderstorms occur and are the source of infiltrating waters that recharge the ground water system. In fact the unsaturated zone at Yucca Mountain is not dry, it is partially-saturated with saturations that range from about 50-90%. In the past (and probably again in the future) pluvial periods of greater precipitation caused ground water levels to rise and lakes to form in basins of Nevada and California. The flux of water through the unsaturated zone at Yucca Mountain is unknown today and unknown for past pluvial periods. The conditions that would allow fractures in the tuffs of Yucca Mountain to transmit water rapidly downward are unknown. It is not known whether fractures transmit water rapidly downward after storms. It is not even known whether the numerous faults are barriers to water flow or act as conduits. The distribution of perched water zones in southern Nevada or in Yucca Mountain are unknown. The controls on the development of perched water zones in the unsaturated tuffs are unknown; as is the nature of water movement in and around them.

Using theoretical models, which have not been confirmed by field-testing, some researchers believe that infiltrating water is drawn into the matrix pores of the tuffs leaving the fractures dry. From these models and limited field observations values of average flux, estimated to be very low, have then been used to show that the travel time of water downward through the unsaturated zone may be very long, tens of thousands of years or more. However, not far away at Rainier Mesa water occurs in fractures far above the water table, and springs emerging from perched water zones have seasonally-varying discharges. If water can move rapidly through fractures in the tuff at Rainier Mesa, which is geologically similar to Yucca Mountain, but receives somewhat higher precipitation, then this could occur also at Yucca Mountain, if not today, then perhaps in a future wetter period.

Many of the answers to the questions about the hydrogeologic system remain unknown, primarily because little study has been made of the hydrologic processes in the geologic setting chosen for the repository. Ground water geology only began as a science about 100 years ago. For many years, studies concentrated on saturated ground water systems in permeable rocks, such as sandstone. Studies of saturated zone fracture flow followed, building on the foundation of the investigations of flow in permeable rocks. Soil scientists were the first to concentrate on unsaturated flow processes, and not until recently have soil scientists and hydrogeologists integrated their research. Prior to the selection of Yucca Mountain as a repository site, very little research of unsaturated zone fracture flow had been performed. In other words, to select Yucca Mountain as the repository site was to choose one of the least-studied hydrogeologic settings possible. To adequately characterize the hydrogeologic aspects of Yucca Mountain, if that is possible, will not only demand investigations of many

processes, but will require development of new techniques and methodologies to investigate the processes in this unfamiliar setting.

Although it may eventually be possible to decide if a repository in Yucca Mountain could keep radionuclides from the accessible environment as required, the investigations in this setting will be difficult, and will not be able to rely on much past experience. Because of this, the time to perform the necessary studies will be long, more than for other simpler or better studied geologic settings. It appears very unlikely that field investigations, laboratory investigations, and computer modeling can be near completion by the 1995 license application deadline. Instead more time and more money will be required to determine if Yucca Mountain will be suitable as a repository site.

The size of the SCP supports the contention that the setting is complex and many studies must begin to investigate the hydrologic, geologic, engineering and other aspects and processes at Yucca Mountain. Perhaps even more disconcerting though, is the lack of detail provided in the description of the proposed geohydrologic investigations in the SCP. This lack of detail appears to be a function of both the complexities and uncertainties of the system, as well as the lack of previous study, which would serve to guide the necessary research.

MAJOR COMMENTS

TIME LIMITATIONS

Many studies, including those investigating: unsaturated zone properties and flow processes, fracture flow, perched water zones, water table configuration and fluctuations, saturated zone flow field, spatial and temporal precipitation patterns, runoff and streamflow, will require many years to design, initiate, collect data, modify, interpret, model and validate. It is unreasonable to suppose that all of these studies can be accomplished by the 1995 license application deadline. Listed below are selected topics that will require more time for investigation.

The investigation of unsaturated zone fracture flow and matrix/fracture interactions under steady-state and transient conditions will require innovative research and development of new field, laboratory and modeling techniques. Conventional unsaturated zone monitoring equipment, such as psychrometers and tensiometers, is geared toward porous media rather than fractured media. Thus the feasibility of collecting meaningful unsaturated zone data, such as water content and pressure head, appears unlikely in the near future.

The current conceptual model of unsaturated zone flow, as explained in Chapter 3, is highly incomplete. At this time, the fundamentals of the most likely pathways for radionuclide transport are poorly understood. To develop and perform the crucial studies of the unsaturated zone hydrology will require a number of years. Based on the results of these studies, detailed conceptual models must then be developed. After more realistic conceptual models are available, numerical models will need to be developed or modified. When these models are available, they will need to be validated. Finally modeling to determine the ground water travel time in the unsaturated zone can commence, if it can be shown that modeling is applicable and can be validated. It is difficult to envision how all of this could be accomplished in the few years remaining until license application.

The chemistry of the unsaturated zone pore water is also important for assessing how radionuclides will react with these waters. The sorptive properties of the unsaturated zone geologic media and the water/rock reactions also need to be known. Our knowledge of this is very preliminary. To improve our understanding will depend on being able to develop and refine sampling methods for extracting pore water from low permeability tuff. The time to develop new methods, collect samples, analyze the data, conduct laboratory experiments, and model the geochemical system is insufficient.

To investigate in detail the water table configuration and its fluctuations over time will require a number of changes to existing studies. Designing and drilling a number of "true" water table wells, with sets of closely-spaced wells near potential recharge areas is needed. In addition the existing water table wells need to be modified so that they penetrate only a few meters beneath the water table. This will require at least several years. Once these new wells are ready, many years (possibly 10 or more) of detailed and continuous monitoring will be required to adequately evaluate the causes of water table fluctuations. This is because the fluctuations may be quite small considering the highly transmissive nature of the saturated media, and the time lag between precipitation events and possible recharge pulses may be long. Analyzing the data under strict quality assurance, lengthens the time for this study past the year 2000.

The time prior to license application for investigating the three-dimensional saturated flow field in the vicinity of Yucca Mountain is inadequate. At this time very little data are available on the saturated flow field, because almost all existing wells sample composite hydraulic heads over 10's to 100's of meters. Several years will be required to analyze existing data, test, and redesign the wells so that they will sample both high-permeability and low-permeability strata. To drill and install at least 10-15 piezometers, each with at least four (4) packed-off intervals, will require more time. Once the system is installed, monitoring will need to occur over a number of years to assess the stability of the flow field and the possible role of coupled processes. Performing all of this under strict quality assurance will produce extremely valuable data, but also lengthens the time for the overall project.

UNCERTAINTIES REGARDING MATRIX AND FRACTURE FLOW IN THE UNSATURATED ZONE

The basic interactions between fracture flow and matrix flow (whether it be for vapor or liquid) are very poorly understood. Of particular importance are transient behavior and conditions when fracture flow might occur, and whether or not Darcian assumptions are valid. Fracture-matrix interactions are also crucial to understanding solute transport, because DOE apparently wishes to rely on matrix diffusion as a radionuclide retardation mechanism. Some of the tracer testing described in the SCP needs modification in order to properly evaluate matrix diffusion.

Stress-testing of the unsaturated, fractured tuffs to determine hydraulic properties using gas (pneumatic) or liquid (water) will require much prototype testing. Moreover, data analysis techniques have yet to be developed for such tests. Yet in the SCP, these tests are presented as if they are routine.

Transient fracture flow through preferred pathways (extreme channelling) is also inadequately discussed. This is probably because detailed investigations in the laboratory and field are only beginning. Because so little is currently known, the SCP should consider all possible scenarios of how moisture moves through the unsaturated zone. Other studies should be conducted to determine the role of fast flow paths, the development of fracture skins and their role in limiting water movement between fractures and matrix, the role of fractures in more permeable geologic media, and the role of tectonics in changing fracture apertures. A serious problem is that reliable technology for measuring transient pulses of water in fractures does not exist and will probably not be ready in time for site characterization studies.

HYDROGEOLOGIC AND HYDROLOGIC CONSIDERATIONS

The unsaturated and saturated zone ground water systems of Yucca Mountain and their interactions are very poorly known. Because of the tectonically active setting, the interactions between the hydraulic and thermal potential fields, and the stress fields need to be investigated. However, the SCP does not adequately address these aspects. The current data on the distribution of hydraulic potential in the saturated zone is very limited. The details regarding the transmissive properties of permeable and less permeable zones in the tuffs are not known and it is unclear whether these will be considered. The geologic media are highly fractured and contain numerous faults that trend roughly north-south, yet the SCP continues to consider these media isotropic.

Theoretical models on which to base aquifer test data interpretation are not well established. These models may need to account for fracture skins, anisotropy, highly-variable hydraulic conductivity zones, and effective porosity in a dual-porosity medium. This, too, points out the need for additional time for site characterization. For those saturated zone tests that are described in relative detail, some testing locations are questionable.

Recharge and discharge processes and their distribution are very poorly known. Recharge is hypothesized to occur beneath the higher mountain ranges and beneath the major washes or their tributaries. However, its temporal distribution and lag between precipitation events and when water reaches the water table is essentially unknown. It is not clear that the proposed studies will allow this to be determined, especially because the number and location of water table wells may be inadequate. Discharge occurs either by springs, or by evapotranspiration. The spring discharge flux can be estimated fairly reliably, however, the evapotranspiration flux, which is more difficult to determine, can only be roughly approximated. This is probably underestimated, which is important because then the recharge flux in the basin or sub-basin will also be underestimated, if a mass balance approach is utilized.

The importance of perched water zones to the unsaturated zone hydrology is just beginning to be realized. These zones must be studied in detail; not only to identify their current extent beneath Yucca Mountain, but also to assess the likelihood of coalescence into large perched water zones. Because of the difficulty of studying perched water zones without compromising the integrity of the tuff at Yucca Mountain, these should be studied in several analog settings, such as Rainier Mesa. Methodology and instrumentation to detect perched water zones should be tested at such analog sites before being applied at Yucca Mountain. The possibility that springs discharging from perched water zones could develop on the flank of Yucca Mountain during wetter periods must also receive greater attention. The SCP states that it may not be possible to characterize lateral flow in the unsaturated zone during site characterization. Lateral flow in and around perched zones must be investigated, if not a potential rapid pathway of radionuclide migration will be ignored.

CONCEPTUAL/NUMERICAL MODELS AND SCENARIO DEVELOPMENT

The conceptual model of the unsaturated zone may need substantial modification, if detailed and well-designed studies are forthcoming. Currently the SCP relies heavily on the concept that most or all of the flux in the unsaturated zone is via matrix flow, which is steady, small, and evenly distributed over the repository block. Although this mode may be important, a wide range of alternative models needs to be considered. Field evidence of rapid water transmission in the unsaturated zone or the existence of perched waters are difficult to explain with the preferred model of steady-state small

unsaturated zone flux. To improve the conceptual model of the unsaturated zone, more emphasis should be placed on field-based testing, especially of analog sites. At these sites, unsaturated zone processes can be studied under different hydrologic and geologic conditions. This will provide a much improved foundation for assessing unsaturated zone flow now and under conditions of increased precipitation. In-situ and laboratory investigations of flow through fractured tuffs, especially of transient processes, must receive much more attention.

Many faults are located within the controlled area and some extend into or through the repository area. Investigations should proceed at several sites to assess the hydrologic behavior of these features. Fault and fault zones could serve as preferred pathways for water movement in the unsaturated zone, and may make this site unsuitable as a repository. Unfortunately, little is currently known about the hydraulic properties of these features. Studies to ascertain this will be difficult to design and quality assure. Inclusion of faults in the unsaturated zone modeling will be challenging.

Fundamental processes governing vapor flow and radionuclide transport in the unsaturated zone at Yucca Mountain are virtually unknown. However, it is very possible that vapor phase flow may represent a fast path of radionuclide migration in relation to Ground Water Travel Time. Furthermore, vapor phase transport of radionuclides conceivably could dominate releases to the accessible environment.

Besides including the above aspects in a modified conceptual model of the unsaturated zone, this model should not be restricted to the site. It is not apparent why so much more effort should be made to construct regional, sub-regional, and site three-dimensional saturated ground water models, when only one unsaturated zone model of the site will be designed. This underscores the fact that our general knowledge of unsaturated flow is so poor, especially in this fractured tuff setting. It is crucial that the unsaturated zone in tuff at other sites, having different hydrologic inputs and outputs than at Yucca Mountain, are studied. This will greatly increase the assurance in our ability to predict the behavior of water today and in the future.

The SCP attempts to portray the geologic media of the unsaturated zone as being readily definable and possessing relatively uniform properties within each unit. However, in the discussion of the saturated zone system the SCP states that such hydrogeologic units cannot be defined for the saturated zone on the basis of hydraulic tests. In reality the geology is highly complex and detailed hydrogeologic facies models for the Yucca Mountain site are not considered in the SCP. A detailed hydrogeologic facies model should be developed that incorporates the natural variability in the volcaniclastic sediments. This variability is the result of the original depositional processes as well as the post-depositional changes. Geostatistical characterization of the hydraulic properties of the geologic formations should then be overlain onto the hydrogeologic facies model. Other models, such as those

incorporating fractal mathematics should be studied to determine if they better approximate the real variability in hydraulic properties. It appears that not enough study of the heterogeneity of hydraulic conductivity or the hydrogeologic facies in the tuffs is planned.

The saturated ground water system will be modeled at a variety of scales and will be monitored via water table wells and piezometers. However, the SCP is vague in its planned modeling. It is not clear how fractures or faults will be incorporated in the models. Anisotropy is definitely important at Yucca Mountain, but receives little consideration in the proposed modeling. The SCP suggests that the saturated system at Yucca Mountain can be reasonably modeled by two-dimensional ground water flow models. However, the apparent very steep water-table gradient and the much higher hydraulic head in the lower carbonate aquifer indicate that the flow field is three-dimensional. Little is currently known regarding the interaction of the tuff aquifer and the lower carbonate aquifer at Yucca Mountain. The values of hydraulic potential at various depths in a number of geologic units, needed to confirm the accuracy of the flow model, are not available and may not be available given the plans for piezometers described by the SCP.

Studies to further refine the conceptual model of the saturated zone should better address coupled flow aspects. It is not apparent from the proposed studies how or if the hydraulic, thermal, and stress fields will be integrated in the conceptual and numerical models.

The site hydrogeologic system should not be restricted to the controlled area. Natural boundaries beyond the controlled area may allow boundary conditions to be specified more accurately for the site hydrogeologic system. For example, a fault may serve as an acceptable boundary, if enough data can be gathered to define the hydrologic parameters at the selected feature.

The understanding of "validation" of models presented in the SCP appears vague. First, calibration is not the same as validation. Second, the validation efforts will be very time consuming.

Of particular concern to the State is the process by which events and scenarios will be formulated. It is not clear in the SCP on what specific bases these scenarios will be developed. Also, it is not clear what role the affected parties will play in developing scenarios.

DESIGN OF WATER-TABLE WELLS AND PIEZOMETERS

Nearly all of the water-table wells and piezometers are not well designed for determining meaningful hydraulic potentials or for collecting representative water samples. The existing piezometers commonly measure composite heads over thick intervals (tens or hundreds of meters) and probably withdraw water unequally from many levels, which cannot be defined. The water table wells commonly penetrate 65-75 meters beneath the water table and thus also measure composite heads. For these reasons the three-dimensional distribution of heads within the saturated zone is essentially unknown. The detailed configuration of the water table and its fluctuations over time are equally uncertain. Chemistry or isotopic data on water samples are also very difficult to interpret, because of the composite nature of the samples.

A better characterization of the saturated ground water flow field will allow better assessment of recharge, ground water travel time, and coupled processes. Defining the flow field is also needed prior to sampling for ground water age determination and for designing natural gradient tracer testing. It also allows improved understanding of results from chemistry and isotopic studies.

Other problems exist besides the design and construction of the wells. There is an insufficient total number of wells and selected areas should have a greater density of wells. In the past, measurement methods have changed often, and values apparently change when the methods change, making time series analyses of water level changes difficult. Calibration problems and drifting of pressure transducer measurements make the available data suspect.

To investigate the water table configuration and changes over time, "true" water table wells should be drilled, or modified by packing off the wells within a meter or two of the water table. The water level monitoring program needs to improve its quality assurance by building in redundancy to pressure transducer measurements and making more frequent calibration measurements. We also suggest investigating the development of alternative technologies for water level measurements in deep wells. These data are extremely important, but if their accuracy is questionable then the data are of limited use. Without properly designed water table wells, it may be impossible to identify water table fluctuations associated with recharge events. Long-term records of water levels must be obtained in order to correlate fluctuations with yearly variations in possible recharge.

Water samples that have been analyzed thus far are composite samples collected from significant thicknesses of geologic formations. This means that the water samples draw from many different flow paths of various lengths and could be mixing water of very different ages. In addition, some ages have been measured for samples withdrawn from wells that have had significant pumpage. Flow lines around these wells could

be highly altered from the original natural flow field and thus the ground water ages may not be readily comparable with samples from wells that have not been pumped.

Attempting to perform geochemical flowpath modeling is more difficult, because the flow field is poorly known at this time. General interpretation of chemistries is made more difficult by the composite nature of the samples. Low-permeability zones may have different water chemistry than the higher-permeability zones, but the higher-permeability zones are probably preferentially sampled when a well is pumped. If there is a vertical component to the natural flow field near a well, the water withdrawn during pumping may also be preferentially extracted from certain intervals.

ESTIMATES OF INFILTRATION

Estimates of infiltration will be very difficult to determine given the geologic media, which is highly fractured. The SCP continues to consider their annual recharge flux estimate of 0.5 mm/yr as conservative, yet no persuasive technical support has been forthcoming. Specific references regarding the techniques by which the various field data (e.g. neutron logging) will be analyzed to determine infiltration need to be established prior to field activities. At this point, it is not clear if the infiltration processes are adequately understood so that testing in the surficial materials at Yucca Mountain will be successful.

CALCULATION OF GROUND WATER TRAVEL TIME

Because it is currently not known whether transient, fracture flow occurs in the unsaturated zone at Yucca Mountain, current estimates of ground water travel time are essentially meaningless. It appears that DOE plans to incorporate non-conservativisms such as matrix diffusion, which is unsubstantiated, and multiple path averaging, which is inconsistent with the regulations, into the estimates for the ground water travel time. The determination of fastest path needs to be based primarily on field testing, rather than modeling. Vapor phase flow may also need to be incorporated into ground water travel time calculations.

DETERMINATION OF THE DISTURBED ZONE

The plans to determine the Disturbed Zone appear to be limited to stress-redistribution analyses and the effects on the rock. However, thermal and physio-chemical processes that affect both the rock and the pore water need to be evaluated.

For example, changes in hydraulic conductivity (not just intrinsic permeability) need to be considered.

WASTE PACKAGE INTEGRITY, HYDROLOGIC CONSIDERATIONS

The discussion in the SCP regarding waste package failure/release processes is too narrow. For example, localized and/or late time corrosion is not adequately addressed. Other factors, such as varying flux conditions and mechanical processes related to stress, are also not adequately considered.

BIASED APPROACH OF THE SCP

A number of biased comments regarding the unsaturated and saturated systems are presented in the SCP. Even though the SCP stresses the need to consider alternative hypotheses, these in fact are de-emphasized. For example, in the early parts of Chapter 3 some alternative models are presented. The later sections, such as the conclusions and summary, essentially only discuss the preferred conceptual models, such as steady-state small matrix flux in the unsaturated zone. Occasional mixing of assumptions and facts also lead to a biased portrayal of the hydrology. For example, the statement that more recharge is occurring beneath Fortymile Canyon is not substantiated by any data, and in fact no water table mound is evident from existing data beneath Fortymile Canyon. The model that more recharge occurs beneath Fortymile Canyon is at this time only a hypothesis not a fact. The conceptual model presented at the end of Chapter 3, is a mixture of solid facts and very tenuous hypotheses.

The SCP heavily cites favorable aspects of reports, such as sections of Montazer and Wilson (1984) and cites unfavorable data or reports, such as sections of Szymanski (1987), much less. An unbalanced approach weakens the overall credibility of site characterization and may allow flawed concepts to be adopted. Misstatements are more commonly favorable for repository siting.

The DOE plans to establish "performance goals" and then work towards meeting these as their approach to issue resolution. However, DOE has not developed adequate contingency plans in regard to issue resolution. For example, what will happen if "performance goals" are not met? Will the goals be lowered, or will there be retesting? It appears the setting of performance goals will be very subjective and it is not clear who will have input to this process.

SPECIFIC COMMENTS

Chapter 3

NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT FORM	
DOCUMENT TITLE: Site Characterization Plan	
COMMENT NO.: 3-1 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.2.2 (3-78)	The number of wells or piezometers used to characterize the regional hydrogeologic system is inadequate in a number of regions of southern Nevada, including an area just north and west of Yucca Mountain. In addition the data only provide a very approximate view of the regional gradient of the saturated ground water system, because the data are collected from springs and wells of various depths.
REVIEWER: Kerry Keen Print Signature	ORGANIZATION: L. Lehman & Associates, Inc. DATE: June 29, 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-2 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.3.1.1 (3-83)	Because of the significant range in ground water temperature and the spatial variability in the chemistry of the water, there is a greater possibility of coupled thermal or tectonic processes acting in the area. Concepts such as those presented by Szymanski, 1987, could apply to southern Nevada and should be investigated in the Yucca Mountain area. REFERENCE: Szymanski, J.S., 1987, Conceptual considerations of the Death Valley groundwater system with special emphasis on the adequacy of this system to accommodate the high-level nuclear waste repository: U.S. Department of Energy.

REVIEWER: Kerry Keen
Print
Signature

ORGANIZATION:
L. Lehman & Associates, Inc.
DATE: June 29, 1989

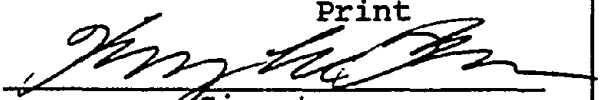
NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-3 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.3.1.1 (3-85)	Significant chemical changes along the flow paths in the carbonate aquifer imply significant addition of water from the tuff aquitard. The chemistry, especially the sodium content, of wells on the eastern side of the NTS is apparently consistent with the concept of movement of water from the tuff aquitard down into the carbonate aquifer. Because this movement is important near Yucca Mountain and because the three-dimensional flow field at Yucca Mountain is very poorly known, flow from the tuff units to the carbonate aquifer should be considered at Yucca Mountain.

REVIEWER: Kerry Keen
Print



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ORGANIZATION:
L. Lehman & Associates, Inc.

DATE: June 29, 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-4 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.3.1.2 (3-93)	The chemistry of water from the valley fill is lower in ionic concentration than the water discharging from the springs at Ash Meadows, which apparently discharges directly from the lower carbonate aquifer. If the more dilute water in the valley fill aquifer in the east central Amargosa Desert, which is lower in elevation and thus drier than Yucca Mountain, is derived from recharge waters, then Yucca Mountain should also be considered as a possible site for significant recharge.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-5 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.3.1.2 (3-94)	Three principal sources of recharge to the valley fill aquifer are identified. However, very little is actually known about the spatial and temporal distribution of recharge in southern Nevada. It is prudent to consider and discuss all possible mechanisms in Chapter 3. Spatially-variable recharge that is widely distributed in space, but variable in time is another possible characterization of recharge in this arid region where heavy rains occur occasionally.

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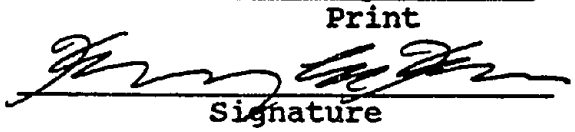
COMMENT NO.: 3-6 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.3.2.1 (3-98)	The correct determination of apparent ground water ages based on carbon-14 content and the apparent lack of "old" waters, is highly dependent upon representative samples of ground water being collected at different positions and depths. In fact, the water samples that have been studied thus far are composite samples. Interpretation of apparent ages, which is always difficult because of the nature of ground water flow where mixing of water of various ages occurs, is even more suspect when the wells sample significant thicknesses of aquifers. These problems are not adequately considered in this section. Lack of "old" water could be the result of water of various ages at different depths being pumped together from a well.

REVIEWER: Kerry Keen Print  Signature	ORGANIZATION: L. Lehman & Associates, Inc. DATE: June 29, 1989

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COMMENT NO.: 3-7 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.3.2.2 (3-102)	There is evidence of megascale channeling, with more rapid water movement, in parts of the carbonate aquifer (Winograd and Pearson, 1976). Because this apparently occurs in the southern Nevada region, then channeling of water flow could occur in the carbonate aquifer beneath Yucca Mountain as well, and could significantly shorten the ground water travel time in the carbonate aquifer. REFERENCE: Winograd, I.J., and F.J. Pearson, Jr., 1976, Major carbon-14 anomaly in a regional carbonate aquifer: possible evidence for megascale channeling, South Central Great Basin: Water Resources Research, v. 12, n. 6, p. 1125-1143.

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DOCUMENT TITLE: Site Characterization Plan	
COMMENT NO.: 3-8 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4 (3-103)	Besides paleohydrologic studies determining the magnitude of increases in recharge, there should be investigations of the changing spatial and temporal patterns of recharge.
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COMMENT NO.: 3-9 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.1 (3-103)	If the potentiometric surface in the Ash Meadows discharge area was 50 meters higher in the past, then the water table upgradient from the discharge area was probably much more than 50 meters higher. As shown by Almendinger (1988), water tables change little in response to increased recharge in the discharge portion of flow systems, whereas much greater rises occur in the upgradient parts of flow systems nearer the ground water divide. Because Yucca Mountain is currently far from discharge locations, increased recharge could cause significant rises in the water table at Yucca Mountain. REFERENCE: Almendinger, J., 1988, Lake and groundwater paleohydrology: A groundwater model to explain past lake levels in west-central Minnesota [Ph.D. thesis]: Minneapolis, Minnesota, University of Minnesota, 123 p.

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COMMENT NO.: 3-10 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.1 (3-106)	Although the role of climate change and its connection to long-term changes in regional water levels is adequately presented, little discussion of the connection between tectonic changes is provided. If little information about the relationships between tectonics and water levels is available then this should be explicitly stated.

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COMMENT NO.: 3-11 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.2 (3-107)	Uranium-disequilibrium ages on calcitic material from southern Nevada and southeastern California commonly yield questionable results. Any ages provided by this method should be identified as being tentative or preliminary.

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COMMENT NO.: 3-12 p. 1 of 2 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.4 (3-111)	A quote is provided from Hunt and Mabey (1966) to provide support for the concept that Lake Manly was of very brief duration and that little field evidence of its existence is present. I have observed good geomorphic and sedimentologic field evidence for the existence of this lake and Hooke (1972) confirms the presence of this lake. Death Valley is one of the most dynamic areas in the Great Basin and the alluvial fans are continually modifying the landscape. For these reasons shoreline features are modified or eroded and only remain in protected or non-eroding locations. The statement on page 3-111: "Resolving whether this lake is closer to 100,000 or 1 million years old..." is a very biased interpretation of the facts. In fact the lake is closer to 10,000 years old, rather than the old ages provided by the SCP apparently in an attempt to support a static view of the dynamics and climate in the Great Basin. REFERENCES: Hunt, C.B. and D.R. Mabey, 1966, Stratigraphy and structure, Death Valley, CA, U.S. Geological Survey Professional Paper 494-A.

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COMMENT NO.: 3-12 p. 2 of 2 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.4 (3-111)	REFERENCES - continued Hooke, R.L., 1972, Geomorphic evidence for Late-Wisconsin and Holocene tectonic deformation, Death Valley, California: Geological Society of America Bulletin, v. 83, p. 2073-2098.

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DOCUMENT TITLE: Site Characterization Plan	
COMMENT NO.: 3-13 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.5 (3-111)	The statement that apparent ground-water ages indicate that much of the ground water within the tuffaceous rocks in the vicinity of Yucca Mountain ... was recharged ... about 10,000 to 18,000 yr ago, is highly questionable. All ground water is a mixture of water that enters the water table at different times. Sampling, especially considering the nature of the wells in the Yucca Mountain area, mixes the water even more. If there is water with an age of 10,000 years, then it is very possible that the sample contains water much less than 10,000 years old as well as water much older than 10,000 years.
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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-14 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.5 (3-111)	The statement "According to Claassen (1985), 'little or no radiocarbon dilution probably occurred during the evolution of water in tuff or tuffaceous valley fill; therefore, the unadjusted ages are taken as true ages.'" is apparently included to support the available radiocarbon ages. In fact, all available ground water ages at Yucca Mountain are highly suspect. Not only is normal mixing along ground water flowpaths a problem, but additional mixing of water of different ages occurs when the existing wells are pumped. This problem is not adequately discussed in the SCP. To imply that the ages listed on pages such as 3-111 are "true ages" is deceiving. REFERENCE: Claassen, H.C., Sources and mechanisms of recharge for ground water in the West-Central Amargosa Desert, Nevada - A geochemical interpretation: U.S. Geological Survey Professional Paper 712-F, 22p.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-15 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.5 (3-112)	The statement "Therefore, ground waters of about the same age as those beneath the upper zone of saturation near Yucca Mountain could have been emplaced 25 to 40 km downgradient." is unclear. It seems to imply some sort of static emplacement of ground water in the past, not a view of ground water as a dynamic system.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-16 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.5 (3-112)	The absence of old waters (>15,000 yr B.P.) in the Amargosa Desert could simply be a result of the sampled intervals in the wells and the three-dimensional flow field beneath Yucca Mountain and the Amargosa Desert.

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DOCUMENT TITLE: Site Characterization Plan	
COMMENT NO.: 3-17 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.5 (3-112)	Given the problems with sampling and highly uncertain knowledge of the three-dimensional flow field, deducing ground water velocities from the limited carbon-14 data is probably not possible.
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DOCUMENT TITLE: Site Characterization Plan	
COMMENT NO.: 3-18 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.6 (3-112)	Conclusion 1 paints a picture of long-term steady water table decline, which projected into the future means drier conditions and deeper ground water levels. Shorter pluvial cycles are superimposed on long-term changes and much of the changes in ground water levels that have been identified could be accounted for by these pluvial/non-pluvial cycles. The number of localities that have been studied and the number of reliable ages are very insufficient to assess the long-term character of climatic and hydrologic change with any certainty. Smith, 1968, provides evidence of cycles of pluviality over the past few million years in southeastern California. REFERENCE: Smith, G.I., 1968, Late Quaternary geologic and climatic history of Searles Lake, southeastern California: Means of correlation of Quaternary succession, v.8, p. 293-310.
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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-19 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.6 (3-113)	Pluvial lakes are expected to be highly variable in elevation and can leave only indistinct evidence of their past presence. The basins in the Yucca Mountain area should be studied very carefully to look for evidence of past pluvial lakes. This task is extremely difficult in this setting where the landscape is constantly being modified, by wind and occasional heavy storms.

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COMMENT NO.: 3-20 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.6 (3-113)	Regarding conclusion 4, our knowledge of recharge in this setting is so sketchy at the present time, that the concept of recharge occurring only beneath the distributaries of Fortymile Wash should remain a hypothesis. Before ages can be interpreted the three-dimensional flow field needs to be much better determined as a basis for sampling. Then ages should be determined at specific locations along flowpaths to determine estimates of ground water velocity. If recharge is concentrated along Fortymile Wash, there should be a tendency for a mound or ground water ridge to develop, especially since the water table gradient is apparently very low in this region. However, no ground water ridge is apparent at this locality. Alternatively a ground water ridge might not be present because either little or no recharge occurs there, or recharge is distributed more widely and occurs in adjacent regions such as beneath Yucca Mountain.

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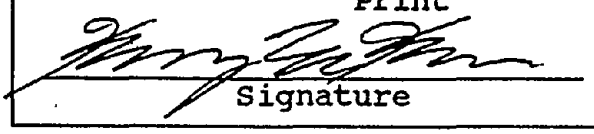

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COMMENT NO.: 3-21 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.8.1.4 (3-130)	Transmissivities are not provided in this section at wells J-12 and J-13. The "slight water level declines" associated with pumping imply that the transmissivities are fairly high here.

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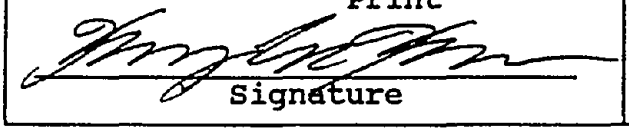
COMMENT NO.: 3-22 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.8.1.4 (3-130)	No information is provided on the distribution system or its source that is described in the statement: "water for site characterization activities would be drawn from wells J-12, J-13 until a distribution system could be constructed."
REVIEWER: Kerry Keen Print  Signature	ORGANIZATION: L. Lehman & Associates, Inc. DATE: June 29, 1989

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COMMENT NO.: 3-23 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9 (3-136)	It is not clear and not explained how downward moisture flow could be offset by upward vapor flow and still have a significant and increasing percentage of saturation with depth in the unsaturated zone, as reported by Sass et al., 1988. REFERENCE: Sass, J.H., A.H. Lachenbruch, W.W. Dudley, Jr., S.S. Priest, and R.J. Munroe, 1988, Temperature, thermal conductivity, and heat flow near Yucca Mountain, Nevada: Some tectonic and hydrologic implications: U.S. Geological Survey, Open File Report 87-649.
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COMMENT NO.: 3-24 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9 (3-137)	Although our knowledge of the distribution and temporal variability of recharge in southern Nevada is very poorly understood, it is not appropriate to say 'if recharge occurs in southern Nevada.' Because there is a regional potentiometric gradient and discharge areas, there must be recharge areas, which are very poorly delineated. It should be presumed that recharge may be occurring at Yucca Mountain, and studies should investigate all possible mechanisms by which recharge occurs. To imply in a number of parts of the SCP that recharge is not occurring at Yucca Mountain, for example: "If any recharge occurs at Yucca Mountain...", diverts attention from the probability that it does occur.
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COMMENT NO.: 3-25 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9 (3-137)	Recharge beneath Yucca Mountain would be better described as joining a three-dimensional saturated ground water flow field and flowing generally east or southeastward. However, the current understanding of the three-dimensional flow field is very poor.

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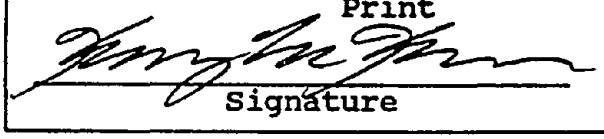

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COMMENT NO.: 3-26 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9 (3-137)	From the water level altitudes for wells in the immediate vicinity of Yucca Mountain, the potentiometric or water table gradient slopes almost directly east. This is perpendicular to the direction of the structural features, the faults and orientation of the mountain, and may imply a strong connection between the hydrologic system and the tectonic setting.

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COMMENT NO.: 3-27 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9 (3-138)	Figure 3-25 and Table 3-22 portray standard geologic and hydrogeologic information in a usable format. However, in this setting where small structures or geologic deposits may be important to ground water movement, several representative diagrams of the detailed stratigraphy and structure at the site would be of use to the reader. These more detailed descriptions could be obtained from analysis of the core data, or from the trench data, and should present hydrogeologic diagrams, in addition to geologic diagrams. Figures 1-21 and 1-22 of the SCP provide some detail of vertical changes in the petrographic character of deposits in two boreholes. Detailed hydrogeologic descriptions are not provided in the SCP.

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COMMENT NO.: 3-28 p. 1 of 1	CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9 (3-142)	The SCP states that "In general, k and K are assumed to vary stochastically within an otherwise homogeneous natural medium with mean values that are spatially invariant ..." This is one conceptual view of the natural variability. Stochastic models may be used to approximate the intrinsic natural variability. This distinction should be stated as such in the SCP. Alternative views should be considered, such as using a fractal model or a mixed stochastic-deterministic model to characterize the variability.

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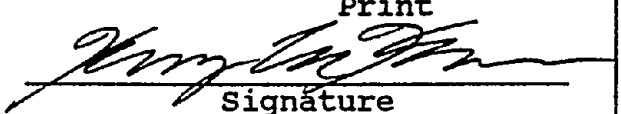

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COMMENT NO.: 3-29 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9 (3-143)	I agree with the SCP that "It is not clear that these approximating representations are appropriate to indurated fractured tuffs, but they have been used in preliminary studies..." The SCP goes on to provide very limited evidence that the traditional soil science functional relationships apply. This paragraph emphasizes the limited understanding that is currently available on the hydrologic system where the repository will be placed. Basic and applied research, which, if done correctly is very time consuming, must be pursued to form a basis for characterizing the unsaturated zone hydrology of fractured tuff. In other words because the proposed repository is in a setting that has received only limited study, site characterization will take longer and probably be more costly than in other more easily characterized settings.

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COMMENT NO.: 3-30 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9 (3-143)	I disagree with the statement: "A hydrogeologic unit, in this usage, is defined to be a functional unit composed of an interval or volume of rocks within which the mean hydrologic properties are effectively spatially invariant." There are probably trends in geologic or hydrologic properties, such as grain-size or composition, within one hydrogeologic unit. For example, a tuff becomes finer-grained with distance from sources (Lajoie, 1984). It is not spatially invariant. Besides requiring an adjustment in our conceptual model, spatial variability of the mean also requires modifications to sampling programs. Not only is there stochastic variability, but also deterministically understandable variability, which requires more sampling to adequately characterize. REFERENCE: Lajoie, J., 1984, Volcaniclastic rocks, in, Walker, R.G., ed., Facies models, second edition: Geoscience Canada, Reprint Series 1, Geological Association of Canada, Publications, Toronto, p. 39-52.

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DOCUMENT TITLE: Site Characterization Plan	
COMMENT NO.: 3-31 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9 (3-146)	The philosophy or approach for developing a conceptual model as stated on page 3-146 appears to be consistent with the overall structure and details of the Site Characterization Plan. However, by only pursuing <u>one</u> conceptual model, which is apparently the preferred model for siting a repository, it may be that alternative models are de-emphasized and thus understudied. The philosophy on page 3-146 should be augmented by Chamberlin's classic 1897 method of "multiple working hypotheses". Here several conceptual models of the hydrogeologic system or processes would be developed, coordinated, and evaluated simultaneously in an impartial manner.
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COMMENT NO.: 3-32 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9 (3-146)	The current state of our knowledge regarding the hydrologic properties of faults as expressed by "...faults may act preferentially either as conduits for or as barriers against moisture flow." is quite amazing. The role of a key component of the hydrologic system of the proposed site is barely understood. The role of faults should probably have been determined before a site was proposed that has faults passing through the controlled area and the proposed repository itself.

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COMMENT NO.: 3-33 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1 (3-147)	Eight (8) or more additional water table wells are planned; however, the water table elevations are not well known at this time because the existing wells sample the hydraulic potentials over 60-75m of thickness of the geologic units. Packers should be placed in each water table well at about 1 meter beneath the currently measured water level. Monitoring should begin in the 1 meter section above the packer as well as in the lower intervals. These changes should be put in place so that monitoring of the actual water table can commence. Once the existing wells have been monitored for 3-5 years, the data should be reviewed as a guide for more-detailed investigations of the water table and for designing and siting additional wells.

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COMMENT NO.: 3-34 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1 (3-147)	It is stated: "Based on available data, it can be concluded that seasonal variations in water levels probably are a fraction of a meter, and no long-term trends have been discerned yet." This sentence implies that long-term trends do not occur, or are so small they cannot yet be detected. In fact, the quality of the available water level data is poor and may not allow determination of trends or periodicities. The quality of the data is poor for two reasons. First, changes in measurement techniques, inadequate calibration methods, and drifting of transducers have called into question all available water level data. Second, the design and construction of water table wells and piezometers, means that composite or average hydraulic potentials are measured. These may show less variability or trends than measures of hydraulic head for thin intervals.

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COMMENT NO.: 3-35 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.1.1 (3-150)	The fact that an apparent perched water zone was encountered in the drilling of borehole UZ-1, which was the first (relatively deep) borehole at the site drilled without water, is very interesting and should have received more attention. Many questions regarding this perched zone are not considered. The concentration of the drilling fluid polymer, its density and viscosity, the volume of fluid lost in comparison to the apparent volume estimated in the unsaturated zone, and the significant lateral transport distances are not discussed. Did the drilling fluid contaminate an already existing perched water zone and cause major changes in its flow field? If G-1 drilling fluid contaminated such a large region around a borehole, then it is also likely that this occurred around other boreholes. This constitutes significant disturbance of the unsaturated zone hydrology in the testing program and in the repository area. Can the site be adequately characterized with such disturbances? Do the disturbances alter the ability of the unsaturated zone to limit downward percolation in the repository area? The SCP only briefly describes the discovery of the water and implies it is all from the drilling of USW G-1.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.1.1 (3-153)	The "...possible long-term drift of the pressure transducers, long equilibration times for the psychrometers placed in dry silica-flour columns, frequency of failure of the heat dissipation probes." again emphasizes the newness of this research and indicates that good quality research on unsaturated zone moisture conditions will take many years to accomplish. Changes in measuring techniques may be necessary to adequately understand the processes. A more systematic approach where all of the technologies were tried, **modified**, and proven on a limited scale prior to general application would provide more confidence in this program.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.1.2 (3-156)	The piezometers in the Yucca Mountain area are 'unusual' piezometers that actually measure composite potentials, commonly over vertical intervals of hundreds of meters. Because of this fact (along with the great inadequacy in the number of piezometers) our current understanding of the three-dimensional flow field is in its infancy. Many additional piezometers that measure potentiometric head of thin intervals are required before much can be learned about the saturated flow system.

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COMMENT NO.: 3-38 p. 1 of 2 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.1.2 (3-156)	The water level measurement errors are unsatisfactory. The measurement errors are roughly the same order of magnitude as the apparent variability in water levels, as determined with the available data (Robison et al., 1988). Thus the data do not permit the determination, with a high degree of confidence, of whether the water table fluctuations are real or are related to errors. Because individual water-level measurements are needed to calibrate the pressure transducer measurements, which are also subject to measurement problems, ("hydrographs of the limited data available might be imprecise and possibly misleading" p. 3-156) confidence in these measurements is even further weakened. Because of the seriousness of the matter for which these measurements are needed, improved technology for accurate water level measurement in deep boreholes should have been a first and high-priority item. It continues to be a high-priority need. I strongly encourage the DOE and USGS to support the development of new technologies in this area.

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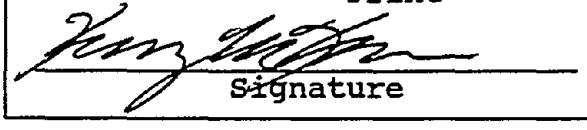

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COMMENT NO.: 3-38 p. 2 of 2	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.1.2 (3-156)	REFERENCE: Robison, J.H., D.M. Stephens, R.R. Luckey, D.A. Baldwin, 1988, Water levels in periodically measured wells in the Yucca Mountain area, Nevada, 1981-1987: U.S. Geological Survey Open-File Report 88-468.
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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.1.2 (3-156)	With regard to the problem of pressure transducer measurements. At the very least a significant improvement in quality assurance of these measurements would be realized by utilizing redundancy. Two (or more) pressure transducers should be used to record water-level fluctuations in water table wells or piezometers. For example, two pressure transducers mounted exactly one-meter apart should record identical water-level fluctuations. Deviations between the pressure transducers would either have to be accounted for (perhaps one drifted as its battery voltage decayed) or if the records could not be reconciled then the value of the records is called into question.

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COMMENT NO.: 3-40 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.1.2 (3-160)	The SCP emphasizes how important precise hydraulic gradient information is to the overall project, in that both ground-water flow direction and travel times are dependent on this information. However, the current lack of true water table wells or piezometers, and the serious problems with obtaining reliable measurements of water levels is in conflict with DOE's statement of the importance of this information.
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COMMENT NO.: 3-41 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.1.2 (3-160)	Comparisons of density, temperature, and chemistry are also complicated because samples of these properties are also composites drawn from thick geologic intervals. Density variation is assumed to be small, however, as recently pointed out by Oberlander (1989) density effects associated with variability in temperature and dissolved solids may be very significant in the Yucca Mountain area. The assumption that fluid potentials are being measured by the water-level measurements in the deep boreholes may be inaccurate. REFERENCE: Oberlander, P.L., 1989, "Fluid density and gravitational variations in deep boreholes and their effect on fluid potential": Groundwater, v. 27, n.3, p. 341-350.

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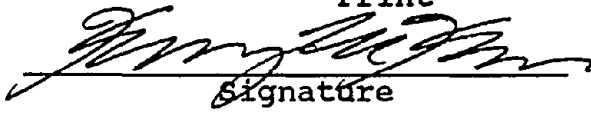

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.3 (3-165)	To determine temporal trends in hydrochemistry, samples should be collected at monthly to quarterly intervals. By sampling at irregular longer intervals any seasonal variations in hydrochemistry may not be discernable. In addition, samples should be collected from water table wells that penetrate only shallowly beneath the water table. The current water table wells probably do not allow detection of seasonal variability of water chemistry at Yucca Mountain.

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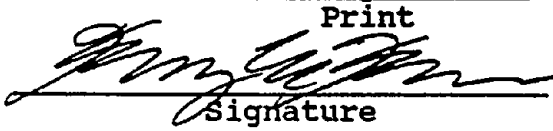

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.3 (3-165)	It should be realized that the available major-ion data are for composite samples, which are withdrawn from a significant thickness of the geologic formations. These samples are mixtures of water that may have quite different original chemistries. Interpretations of the available and other forthcoming chemistry data from the wells at Yucca Mountain are very difficult to make. Determining whether the water appears to be super-saturated, undersaturated, or in equilibrium with specific minerals within the tuffs at a given level cannot be ascertained from composite samples. In addition, because kinetics may also play a role and the composite samples may include water of very different residence times, part of the water may have had time to reach equilibrium whereas other parts may not have had time to attain equilibrium.

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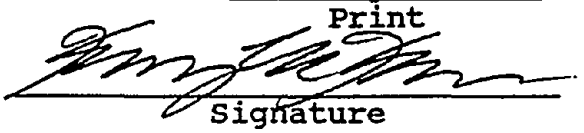

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.3 (3-165)	The water chemistry of the lower-permeability zones in the tuffs may be different from the water chemistry of the higher-permeability zones. Selective sampling of the higher-permeability zones probably occurs when the wells are pumped to collect a sample.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.3 Table 3-25	A column that indicates the depth interval from which the samples are taken should be included.
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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.3 (3-168)	The delta carbon-13 values of ground water samples are negative and are consistent with recharge under very poorly vegetated conditions. This may suggest that water, even at significant depth, was probably recharged in the Holocene. During the maximum-Wisconsin (20,000-15,000 yr. B.P.), vegetation patterns deduced by paleobotanical methods are consistent with greater vegetation cover and less negative delta carbon-13 values are expected. During the early Holocene pluvial period the vegetation cover was probably greater than today, but may not have been as much as in the Pleistocene, because the vegetation composition does not appear to have changed much at this time.

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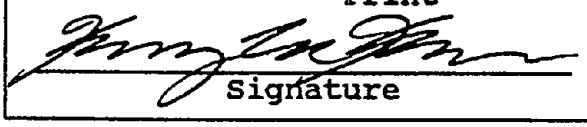

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.3 (3-167) Table 3-25	Why are the values listed for HTO given as less than certain values rather than providing the measured value? This should be explained on the Table or in the text. Pre-1950 values of tritium are approximately less than 5 or 10 tritium units, whereas tritium levels after the major atomic tests (50's-60's) are commonly 1000's of tritium units. If the values listed as <62 tritium units are close to 50 or 60 tritium units, then this could indicate that the water contains some recent water. If the values are less than this then the water may be somewhat older or very old. The fact that water has tritium values apparently > 6.0 TU is significant. Because the half-life of tritium is 12.3 years and because the samples are typically composite samples of water, the existence of significant measurable tritium values may indicate that some relatively young water is being incorporated.

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COMMENT NO.: 3-48 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.3 (3-168)	Because "methods are currently under development for extracting uncontaminated samples upon which to perform these [hydrochemical and isotopic] analyses", the ability to use geochemical information on pore water to assess the residence time and chemical evolution of water as it passes through the unsaturated zone remains in doubt. Once methods are developed and tested, which will most likely take at least several years, the actual sampling will need to proceed at a number of sites and depths. Thus it appears there will probably not be enough time to have gathered and analyzed the samples prior to the 1995 license application deadline.
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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.3 (3-168)	It should be clearly stated that the possible "downward gas-phase transport from the surface" is only implied at site UZ-1. The possible downward transport is unknown for the rest of Yucca Mountain. In other words the highly tentative interpretation of radiocarbon-activity profile at one site should be clearly stated as such. The SCP should not presume that data collected at one site is representative of the entire site.

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COMMENT NO.: 3-50 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.2.1 (3-169)	Tuffs may have crude bedding, oriented in a horizontal or subhorizontal manner, and thus may be somewhat anisotropic with respect to water flow. Measurements of hydraulic conductivity of samples from cores, which are vertically oriented, are probably underestimating the maximum matrix permeabilities.

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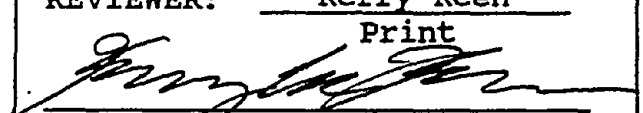
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.2.1 (3-170) Table 3-26	The normal or expected statistics, such as range or standard deviation of K values and the number of samples these values are based on are not provided for each unit. By only listing one value a sense that the value is accurately known is presented.
REVIEWER: Kerry Keen Print  Signature	ORGANIZATION: L. Lehman & Associates, Inc. DATE: June 29, 1989

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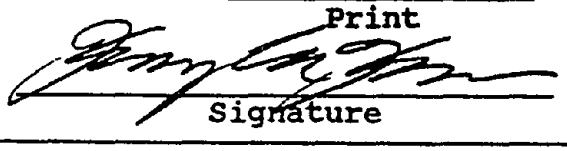
COMMENT NO.: 3-52 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.2.1 (3-171)	Regarding: "Techniques for the measurement of relative hydraulic conductivity on very low permeability tuffs, such as welded tuff matrix material from TSw, are under development,..." Because detailed measurements of permeability in these tuffs are unavailable, understanding the flow of fluids in the unsaturated zone remains highly speculative. This data is important in understanding the mechanics of vadose zone flow. To obtain this important data, upon which other experiments will need to be designed, will take at least several years if it is possible. It appears the time needed for this work is insufficient. Proceeding with other experiments prior to the measurement of this property may result in improperly-designed field experiments.
REVIEWER: Kerry Keen Print  Signature	ORGANIZATION: L. Lehman & Associates, Inc. DATE: June 29, 1989

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.2.1 (3-171)	Regarding: "Standard field and laboratory methods are not yet available by which to determine the moisture-characteristics relations for variably saturated fractures and fractured rocks." The time to develop methods for understanding moisture characteristics of fractures and fractured rocks is insufficient. Once the methods are available they need to be applied across Yucca Mountain at various depths. Sampling and analyzing the results of measurements will require additional time. Because of the importance that fractures may play in transporting water in the unsaturated zone, this data is very important and should be known and available as a foundation for site characterization. It should not be a part of site characterization. This lack of understanding is an example that supports the site being not "readily characterized."

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.2.1 (3-171)	The selection of Yucca Mountain as a potential repository site is based on theoretical concepts of how moisture may behave in the unsaturated zone in this setting. The SCP states that "Theoretical models for liquid-water flow in single fractures have been developed but have not yet been field or laboratory tested." In other words our understanding of the flow of water through this material is in its infancy.

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COMMENT NO.: 3-55 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.2.1 (3-174) [3-34]	This is a highly idealized figure. It may apply in steady-state, uniform flow conditions, but is untested in transient conditions or in examples of real fractures possessing variable apertures and connectiveness.
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COMMENT NO.: 3-56 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.2.1 (3-175)	Besides being dependent on the parameters listed, the net effective hydraulic conductivity may also be a function of the transient conditions.
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COMMENT NO.: 3-57 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.2.1 (3-178)	Porosities should ideally be determined on the same samples for which moisture contents are determined. The values of saturation should be taken as estimates. The range or confidence intervals should be provided. As the SCP states, these are very tentative results.
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COMMENT NO.: 3-58 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.2.1 (3-178)	The discrepancy of TSw matric potentials measured in UZ-1 and estimated from moisture contents highlights the fact that we may not yet have reasonable conceptual models for the unsaturated zone water system.
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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.2.2.1 (3-181)	The SCP should be consistent and report hydraulic conductivity values in the same units, preferably m/s. Switching between m/s and m/d only makes comparisons more difficult.

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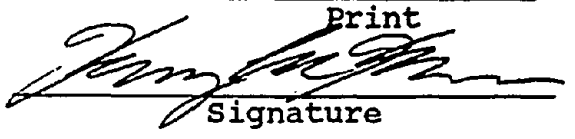

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COMMENT NO.: 3-60 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.2.2.2 (3-187 to 3-190) Table 3-28	The available values of hydraulic conductivity, reported on Table 3-28, may be unrepresentative of the true hydraulic conductivities, because of the biased sampling related to the respective orientation of the boreholes and the fractures, which are both oriented vertically. The permeable zones identified by the sampling program, may in fact be locations where fractures or fracture sets and boreholes intersect. Other levels may have higher conductivity, but fractures at those levels may not be intersected by a particular borehole.
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COMMENT NO.: 3-61 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.3 (3-193 to 3-197)	The conceptual model and hypotheses listed are biased towards a favorable model for repository siting. Alternative hypotheses should be listed and given fair consideration. The biggest concern with this approach is the danger that testing may be essentially restricted to these hypotheses and other concepts may not be investigated.
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COMMENT NO.: 3-62 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.3 (3-193 to 3-214)	Alternative models or aspects of models are not sufficiently discussed in Chapter 3. For example in section 3.9.3 possible linkages between changes in water tables or potentiometric levels and fault block movements are not considered. These are probably minor transitory effects, but the importance of such factors should be investigated. Another physical mechanism that is not discussed in Chapter 3, either in sections 3.9.3 or 3.7.4, is the possibility of changes in tectonic activity associated with changes in the hydrologic system. For example, when pluvial lakes form and when they disappear, the crust must isostatically adjust. By this mechanism greater earthquake activity and faulting may be expected as pluvial lakes form and as they wane. Thus present faulting rates may be less than the rates occurring at such times.
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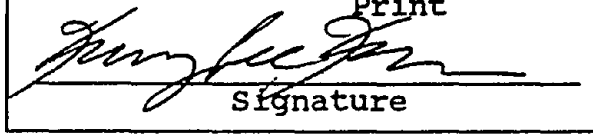
COMMENT NO.: 3-63 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.3 (3-194) [3-40]	If hypothesis 3 is correct and water is less likely to flow into the matrix of TSw from PTn, then the offsets and hydraulic nature of the faults become very important. For example on Fig. 3-40, offsets of the PTn unit are shown that do and do not separate it from itself. If faults are transmissive features, then it is imperative the detailed geometries and offsets of these units are determined.
REVIEWER: Kerry Keen Print  Signature	ORGANIZATION: L. Lehman & Associates, Inc. DATE: June 29, 1989

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COMMENT NO.: 3-64 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.3 (3-196)	A concept that may be important to the siting of a repository at Yucca Mountain, is that the non-welded units, eg. CHn, transport water essentially only by matrix flow. However, fractures do exist in these units and although they are less frequent, questions remain as to their role in water movement. First of all, are they continuous with fractures in the overlying and underlying units? Are there zones of greater concentration of fractures that serve as preferred pathways? Are fracture skins important in these units, as they may be in the welded tuff units?
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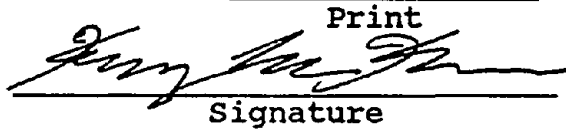
COMMENT NO.: 3-65 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.3 (3-197)	It is conceivable that ground water in the Yucca Mountain vicinity could have significant interaction with ground water of the lower carbonate aquifer. The SCP reports that a significantly-higher head in the carbonate aquifer has been discovered in one well on the east flank of Yucca Mountain, where the water table is relatively low and has a gentle gradient. However, the head relationship between the tuff and carbonate aquifers is unknown in the western and northern parts of Yucca Mountain where the water table is apparently much higher. Is recharge favored in these regions? Could there be a movement of water into the lower carbonate aquifer in this region?
REVIEWER: Kerry Keen Print  Signature	ORGANIZATION: L. Lehman & Associates, Inc. DATE: June 29, 1989

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DOCUMENT TITLE: Site Characterization Plan	
COMMENT NO.: 3-66 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.3.1 (3-199)	This section seems to consider only vertical downward flow in the unsaturated zone. In a complex fracture network, the flow may have lateral components, which may become more important near perched-water zones.
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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.3.2.1 (3-200)	Regarding: "Although the data show considerable variability, there is no well-defined systematic variation of matric potential with depth within hydrogeologic units, which is consistent with the supposition that the individual hydrogeologic units are relatively homogeneous in the vertical direction and that steady-state vertical moisture flow occurs under unit vertical hydraulic gradient." This statement is an example of the biased presentation of Chapter 3. This statement strongly over-interprets the data. Figures 3-30 and 3-31 indicate both significant vertical variability, as well as possible complicated patterns of changes in potentials over time. In addition, no details on the time response of the sensors are provided. Could rapid flow of a pulse of water in fractures be missed by this monitoring system?

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.3.3 (3-203)	This section presents a biased or narrow, unsubstantiated view of moisture movement in the unsaturated zone. The statement: "Temporal variations of net infiltration <u>are expected to be</u> damped rapidly with depth in the uppermost few tens of meters of the unsaturated zone..." should be altered to read clearly as a hypothesis, not an expectation. Instead of the expectation that "slow temporal variation of moisture flux at any horizon" is a response to long-term climatic change, a more balanced set of hypotheses should be stated. These include the stochastic nature of infiltration as well as stochastic aspects of flow through the unsaturated zone. This section does not give fair consideration of other hypotheses. If flow through fractures is important, then the entire discussion of unsaturated flow must be changed.

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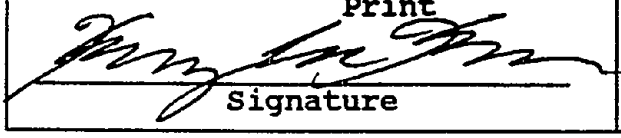

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.3.4 (3-208)	This section repeats many previously stated assumptions as "quasi-facts." There seems to be a pattern of introducing hypotheses early in Chapter 3 and repeating them several times later in the chapter. By the end of the Chapter, however, the conditional clauses may not appear with the hypothesis, which by this technique, is given more weight.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.4.1 (3-216)	Ground water travel time calculations for the unsaturated zone are extremely premature, because conceptual models of flow mechanisms and patterns have not been compared with reality by field testing. Although it is interesting to calculate estimates of travel times, the possibility of rapid flow through fractures that may be contiguous for many meters or tens of meters means that the travel times (and range in estimated travel times) based on slow matrix flow may be very much larger than the actual travel time. A better approach would be to estimate travel times for a number of alternative scenarios, not just for the preferred matrix-flow model.

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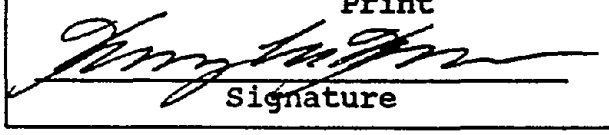

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COMMENT NO.: 3-71 p. 1 of 2 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.4.2 (3-219)	Regarding assumption 3: The available water level measurements are not detailed enough to provide reasonable estimates of the water table or hydraulic gradient because they are composite measurements. The gradient is probably underestimated in some areas. In addition the possibility of localized semi-perched water zones (see Winograd and Thordarson, 1975) and the interaction of this water with the water table surface is not discussed. Regarding assumption 4: Because vertical fractures exist, anisotropy may be very significant. Boreholes probably do not intersect a representative number of fractures and thus most likely underestimate both storativity and transmissivity. In addition, fracture aperture, density, and orientation are dependent on the tectonic stress field, which may vary spatially and temporally. Thus the system may be far from isotropic as assumed.

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COMMENT NO.: 3-71 p. 2 of 2 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.4.2 (3-219)	REFERENCE: Winograd, I.J., and W. Thordarson, 1975, Hydrogeologic and hydrochemical framework, South-Central Great Basin, Nevada-California, with special reference to the Nevada Test Site: U.S. Geological Survey Professional Paper 712-C, p.C1-C126.

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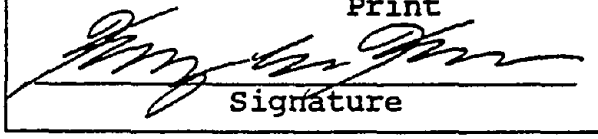
DOCUMENT TITLE: Site Characterization Plan	
COMMENT NO.: 3-72 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.8 (3-229)	It appears that zeolitization of tuffs is favored at or beneath the water table, and thus the lowest elevation of vitric tuff may allow determination of paleowater tables. This concept is interesting and could be quite useful if verified for the southern Nevada region. The lowest elevation of vitric tuff should be identified in other parts of southern Nevada to see if these surfaces could possibly approximate paleo-water levels. Investigations should also proceed to determine if zeolitization can occur in perched water zones. A much more thorough documentation of the three dimensional geometry of vitric versus de-vitrified zones may be necessary prior to concluding that this boundary may approximate the paleo-water table.
REVIEWER: Kerry Keen Print  Signature	ORGANIZATION: L. Lehman & Associates, Inc. DATE: June 29, 1989

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COMMENT NO.: 3-73 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.8 (3-229)	The Czarnecki model and estimates of changes in recharge are valuable learning tools developed on the basis of the best available information. Although these modeling efforts are quite detailed and appear to be reasonable, we must remember that they are only one representation that approximates the actual hydrologic system. The results of the ground water modeling and recharge estimation are not substitutes for the actual processes or values. Czarnecki's model rests on a number of assumptions, which are subject to modification as new data are obtained. For example, the detailed timing and transient nature of infiltration over the Yucca Mountain surface in the past is unknown at this time. Significant recharge may have occurred along faults or beneath depressions on the mountain surface in the past.

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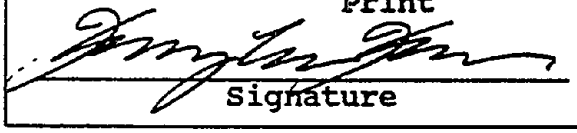

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.10.1 (3-235)	The modeling of flow in the unsaturated zone seems to apply circular reasoning. By presuming steady-state flow, the results show (as expected) that the flow through the unsaturated zone is steady and slow in the matrix. Investigations of stochastic or chaotic flow processes in the unsaturated zone are not reported here and realistic modeling of highly transient fracture flow has not been reported yet.

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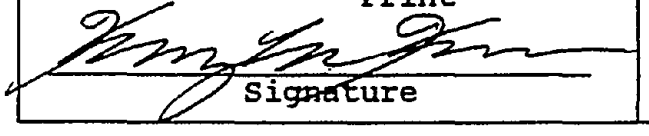

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COMMENT NO.: 3-75 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.10.1 (3-236)	The conclusions regarding the flow of water in the TSw unit are not conclusions, but rather are hypotheses developed from the available limited data.

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COMMENT NO.: 3-76 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.10.1 (3-236)	It may be necessary to analyze gas flow as a multicomponent system, Thorstenson and Pollock (1989), especially for radioactive daughter products. Fluxes may arise from small pressure differentials, which presents a problem because these are presently at the current detection limit for differences in gas pressures. REFERENCE: Thorstenson, D.C. and D.W. Pollock, 1989, Gas transport in unsaturated zones: Multi-component systems and the adequacy of Fick's Laws: Water Resources Research, v. 25, p. 477-507.

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COMMENT NO.: 3-77 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.10.1 (3-237)	Travel times are listed given the assumption that matrix flow dominates. The preliminary nature of these estimates should be emphasized. Travel times should also be estimated for other scenarios, including rapid transient fracture flow in preferred pathways via fracture networks.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.10.1 (3-237)	A value of 200 meters is listed here as the distance that the water table would have to rise to inundate the repository. From figure 3-41, a rise of 185 meters is needed to flood the lowest part of the repository, whereas a 135 meter rise would bring the level to the limit of the disturbed zone.

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COMMENT NO.: 3-79 p. 1 of 2 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.10.2 (3-238)	The SCP argues that if perched-water bodies are found at Yucca Mountain, they are not a major concern. No evidence or basis for this statement is offered. First of all, the presence of perched water bodies means fractures are saturated, which is exactly opposite of what the model of flow in the unsaturated zone is based on. This would be very serious and would indicate the preferred model may be flawed. Secondly, because flow through fractures is more rapid than through the matrix, the travel times through the unsaturated zone may be much less. It has not been established perched-water zones are static features with stagnant water. In fact, the variable discharge of perched-water springs as reported by Winograd and Thordarson, 1975, indicates perched water may be highly dynamic. If flow systems exist within perched-water bodies and if springs emerge from them now or in the future, this may be a rapid transport path for radionuclides to the accessible environment.

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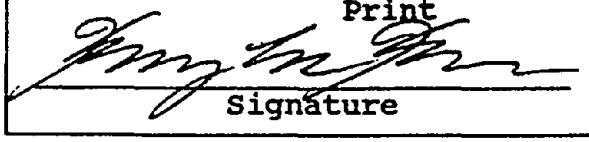

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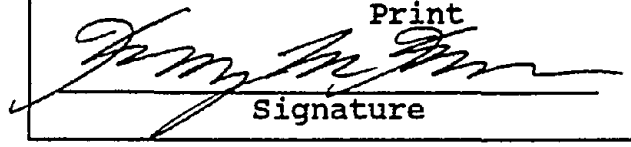
COMMENT NO.: 3-79 p. 2 of 2	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.10.2 (3-238)	REFERENCE: Winograd, I.J., and W. Thordarson, 1975, Hydrogeologic and hydrochemical framework, South-Central Great Basin, Nevada-California, with special reference to the Nevada Test Site: U.S. Geological Survey Professional Paper 712-C, p.C1-C126.
REVIEWER: Kerry Keen Print  Signature	ORGANIZATION: L. Lehman & Associates, Inc. DATE: June 29, 1989

SPECIFIC COMMENTS

Chapter 8

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COMMENT NO.: 8-1 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.0 (8.0-5)	The preferred conceptual model for the site is used in this discussion. For example it is stated: "As explained in detail in Chapter 3, the currently available information suggests that only small amounts of water are available to percolate slowly downward through Yucca mountain." In reality very little field evidence is available for determining the actual rates at this time. A more balanced statement of this should be used at this time, which acknowledges the uncertainties in the current understanding of water movement in the unsaturated zone at Yucca Mountain.

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COMMENT NO.: 8-2 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.0 (8.0-8)	The preferred conceptual model is relied on too heavily in the discussion on the performance of the engineered barrier system. Whether or not an air gap around the containers will be effective in keeping water from contacting the containers is unknown. It depends on the nature of flow in the unsaturated zone, which at this time is highly uncertain. The role of transient fracture flow and the behavior of the perched water zones are essentially unknown at this time. The SCP is less credible or possibly flawed when it selectively adopts preferred conceptual views as a basis for its engineering design.

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COMMENT NO.: 8-3 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.0 (8.0-8)	The statement: "Current evidence suggests that the travel time from the repository through the unsaturated units to the saturated zone is longer than 10,000 yr." should be modified to: "There is limited preliminary evidence, based on highly incomplete field study and modeling of matrix flow, that the travel time through the unsaturated units to the saturated zone is long, possibly greater than 10,000 years. Alternative models such as localized highly transient fracture flow are of concern because these could yield travel times that are much less than 10,000 years, especially given the uncertainty about future precipitation and recharge patterns." Again the SCP is assuming the most favorable conceptual model of flow and geochemical interactions in the performance of the natural barriers, and under-emphasizes the possibilities of rapid fluid transmission along fractures, the role of faults and tectonics, the behavior of perched water zones, etc.

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COMMENT NO.: 8-4 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.0 (8.0-9)	The statement: "The top-level strategy focuses strongly on the investigations of the characteristics of the flow in the unsaturated zone, relying heavily on the current view that the percolation flux is low and that the water in the unsaturated zone is tightly confined within the rock matrix." is a questionable strategy. Instead of "relying heavily" on one favorable model, there should be intensive investigations based on a variety of conceptual models to prove that other models do not apply or are not important. It is conceivable that by performing tests within the framework of one preferred conceptual model, the tests could all support the validity of the preferred model. However, tests of alternative models may explore aspects of the real system not previously considered, and may allow the detection of flaws in the original preferred conceptual model. Alternative conceptual models should not be relegated to "second place" concepts, or tucked in a short list of topics "that will also be studied." Alternative models should receive equal status.

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COMMENT NO.: 8-5 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.1.2 (8.1-5 thru 8.1.6) [8.1.1]	As presented in the figure on page 8.1-6, the Issue Resolution Strategy is missing an important feature. A feedback loop should extend from Step 9 "Establish That Information Needs Are Satisfied" back to Step 6 "Develop Testing Strategy, Identify Tests, Variables and Parameters to be Measured". This feedback loop is necessary in case it is determined during Step 9 that a particular information need has not been satisfied. Such situations are highly likely, particularly when dealing with subsurface investigations where unforeseen results are commonplace.

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COMMENT NO.: 8-6 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.1.2.2 (8.1-7 thru 8.1-8)	The use of performance "goals" is questionable. The DOE defines these goals as guides which will have specific values consistent with licensing strategies. Once these "goals" are attained, then supposedly an issue will be resolved. The DOE however proceeds to caveat this rationale to the extent that it becomes useless. All goals do not have to be met, they are only preliminary, they can be changed. Once again, DOE has rendered a good idea useless. No steps have been outlined as to what happens when goals are not achieved within confidence limits. Does the DOE simply change the goal to meet the value?

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COMMENT NO.: 8-7 p. 1 of 1	CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.1.2.2 (8.1-8)	Typically confidence intervals are statistically rigorous quantities. DOE states that most of their confidence indicators are only qualitative expressions. DOE is trying to make a completely arbitrary process appear to be mathematically grounded.

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COMMENT NO.: 8-8 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.1.2.3 (8.1-8)	Again, DOE is setting a goal of a specific value for a parameter. Caveats are many; the goal does not have to be met, the goals are preliminary, etc. Again, this implies that if a parameter does not live up to expectations, expectations will simply be lowered. DOE should be required to have a strategy that if a parameter fails an expected goal, then other goals should be made much higher in order to compensate the failed goal. No such statements are made by DOE.

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COMMENT NO.: 8-9 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.2.1 (8.2-3) Table 8.2-2	The SCP lists the information needed for Key Issue 1.1.2 as: "A set of potentially significant release scenario classes that address all events and processes that may affect the geologic repository." This states that information is needed on a wide range of possible scenarios and emphasizes the importance of considering alternative conceptual models. This conflicts with other portions of Chapter 8 where the current preferred model is emphasized and alternative models receive little discussion.

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COMMENT NO.: 8-10 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.2.1.2 (8.2-21) thru (8.2-27) Table 8.2-3	Table 8.2-3 lists "concerns" along with corresponding "SCP cross-references", but a number of cross references are incomplete, or inadequately address the stated concerns. This table leads the reader to believe that the specific concern has been addressed or resolved as stated in the cross reference. The table should not state that the concerns are addressed, which implies some resolution of the concerns. Instead it should state that "...relevant discussion of the concern is included in the cross reference." A number of concerns are correlated with SCP sections that seem to discuss peripheral or slightly related issues. For example on page 8.2-23; major concern: Hydrogeologic properties; specific concern: Interrelationships of hydrogeologic properties; SCP cross-reference is 3.6 Regional hydrology. I interpret the stated concern to be about the detailed correlation between properties such as transmissivities, porosities, anisotropies, hydrogeologic formation geometries for specific units. This is not discussed in 3.6. Another example is on page 8.3-27 where a concern on groundwater migration in the Great Basin is correlated with SCP sec. 1.1, which is about Great Basin Geology not groundwater migration.

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COMMENT NO.: 8-11 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.2.1.2 (8.2-22) Table 8.2-3	Hydrothermal activity and its affects on flow paths does not necessarily require faulting and should not be correlated with an SCP section that discusses the effects of faulting.

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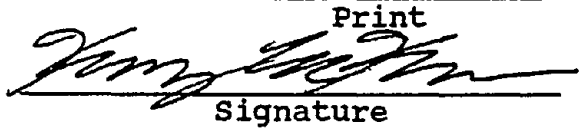

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COMMENT NO.: 8-12 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.2.2 (8.2-65) Table 8.2-6	The Potential for coupling of tectonic and hydrologic processes and events should be addressed by a Corresponding Issue in the SCP. Regulations supporting the study of this topic include 10 CFR 60.113 a(2) and 10 CFR 60.122 c(4).

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.1 (8.3.1.1-4)	The geologic record does offer the opportunity of looking at long-term processes at Yucca Mountain. However, the statement that the mountain formed more than ten million years ago paints a static view of the site and is inaccurate. The volcaniclastic units were deposited at that time. The mountain itself is a dynamic feature of the present landscape.

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COMMENT NO.: 8-14 p. 1 of 1	CHAPTER NO.: 8
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.1 (8.3.1.1-5)	If an issue is "resolved" and then future information becomes available that sheds doubts about the previous resolution, there should be a mechanism for making an issue "un-resolved" again. This needs to be described in the SCP.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-3)	Restricting the development of the unsaturated zone hydrologic model to the site is unwise. A more comprehensive study of the regional unsaturated zone is definitely warranted. Analogs for the unsaturated zone at Yucca Mountain, especially those with a somewhat different hydrologic regime, such as higher annual precipitation and infiltration, should be identified and studied in detail. Because the unsaturated zone is relied on as the most important natural barrier, and because there are many questions regarding the hydrologic system in the unsaturated zone, this zone deserves intensive investigation. Hydrologic conditions will change over time at Yucca Mountain. Studies of the unsaturated zone in similar geologic media, but with higher precipitation, greater recharge, more extensive perched water zones, etc., may provide data that reduces the uncertainty regarding the behavior of water in the unsaturated zone.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-10) Table 8.3.1.2-1	The studies identified in Table 8.3.1.2-1 are valuable and definitely necessary. However, many of the studies listed, especially the meteorological and unsaturated zone studies, require many years of investigation to characterize the natural variability of the processes. The time allotted until the proposed submittal of the license application is too short for the level of research that is needed. If these studies had begun 10 years ago then perhaps there would be time to conduct high quality detailed research that can accommodate modifications as data is collected. The proposed studies can essentially only proceed as designed and there will be little or no time to modify or revise the approaches as preliminary data is collected.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-20) Table 8.3.1.2-1	Studies of three dimensional potential fields in the matrix and adjacent fractures, and also in and around perched water zones are not listed and should be included in the investigation of water potential in the unsaturated zone.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-22) Table 8.3.1.2-1	Studies of temperature variations after heavy rainfall events are not listed and should be included. Pulses of cool water from winter rains may be detected relatively easily in the unsaturated zone.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-28) Table 8.3.1.2-1	The boundary conditions for the unsaturated zone flow and solute transport numerical models do not include variable or non-steady boundary conditions, but these may be important and should be included.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-49)	The statement that "... and hydrologic processes are slow and difficult to measure." can characterize certain processes, but is extremely inaccurate in the characterization of storm precipitation, runoff, and in certain settings, infiltration and recharge. The statement follows the overall pattern in the SCP of characterizing the hydrologic system in a favorable light for repository siting.

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COMMENT NO.: 8-21 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-52 thru 8.3.1.2-87) Tables 8.3.1.2-2a thru 8.3.1.2-2b	Commonly, the listing of the "current representation" and the "alternative hypotheses" on tables 8.3.1.2a and 8.3.1.2b are equally uncertain. In a number of instances the only distinction appears to be that the current representation is preferable for repository siting. This strategy is not balanced or fair. A better approach would be to list all hypotheses as "hypotheses", rather than subjectively selecting the "current representation" and "alternative hypotheses."

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COMMENT NO.: 8-22 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-52) Table 8.3.1.2-2a	The uncertainty regarding the definition of the unsaturated zone should be considered to be greater because perched waters or semi-perched waters, similar to those described by Winograd and Thordarson (1975), may exist at the site. This would complicate distinguishing between the saturated and unsaturated zone. REFERENCE: Winograd, I.J. and Thordarson, W., 1975, Hydrogeologic and geochemical framework, South-Central Great Basin, Nevada-California, with special reference to the Nevada Test Site: U.S. Geological Survey Professional Paper 712-C, p. C1-C126.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-52) Table 8.3.1.2-2a	The alternative hypothesis for the stratigraphy model element may characterize the stratigraphy as well as the current representation does. These should both be stated as alternative hypotheses rather than listing the preferred representation as the current representation. The uncertainty here is medium or high. As stated on page 8.3.1.2-89 of the SCP, clearly defined hydrogeologic units have not been established. These units are dependent on a detailed geologic process/depositional model and hydrogeologic model for the site, which are not available. The need to reduce uncertainty should be high, not low. The system is difficult to define because of complex depositional processes. Stochastic or other statistical characterization of hydrogeologic properties will only partially succeed in approximating the true deterministic system. Other representations, for example applying fractal mathematics, may be preferred over traditional statistical methods.

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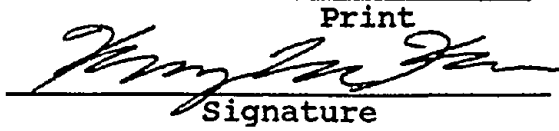

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COMMENT NO.: 8-24 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-53) Table 8.3.1.2-2a	The uncertainty of the transient, non-equilibrium flow of water in open fractures and faults should be listed as high not medium at this time. Although some modeling suggests that this is not an important process, field evidence that is consistent with more rapid transmission of water through the unsaturated zone indicates that this topic may be highly uncertain.

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COMMENT NO.: 8-25 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-53) Table 8.3.1.2-2a	Although there is low uncertainty that fractures and fracture systems are conduits for air and water-vapor flow in fractured tuffs, there is high uncertainty regarding the spatial and temporal variability of this flow. It is unknown if there are zones of enhanced gas flow or zones of diminished gas flow.

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COMMENT NO.: 8-26 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-53) Table 8.3.1.2-2a	An overall criticism of Table 8.3.1.2-2a, especially the structural features section, is that the alternative hypotheses are inadequate or overly simplified. More complex, but realistic hypotheses are not provided, for example: preferred pathways, combination of transient conditions and preferred pathways, heterogeneity of moisture conditions, which reduce air/vapor flow locally. We cannot rely on average conditions to understand the entire range of processes acting in a system.

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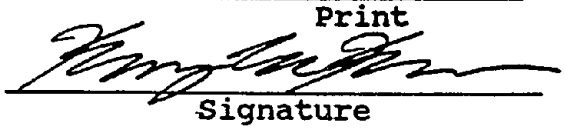

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-54) Table 8.3.1.2-2a	Regarding the lateral flow of liquid related to eastward dipping fault blocks; lateral flow in the unsaturated/variably saturated zone could be strongly controlled by the structural dip of the geologic units, but could also be enhanced near and within perched water or semi-perched water zones. Because there is a possibility that springs could emerge from such perched water bodies, as identified elsewhere in southern Nevada (eg. Winograd and Thordarson, 1975), and because this could be a pathway for radionuclides to the accessible environment, the need to reduce the uncertainty regarding three-dimensional flowfields and interaction with perched water bodies is very high. The SCP states (p. 8.3.1.2-54) that "a complete description of this process probably is beyond the scope of the site characterization program." This is a serious weakness or omission of the site characterization program. To not study a possible transport mechanism or an aspect of a process, which conceivably could play a major role in allowing radionuclides to reach the accessible environment, is of major concern and indicates a selective approach to the study of potential problems. This is

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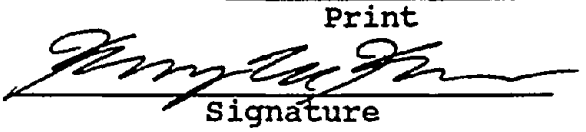
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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-54) Table 8.3.1.2-2a	contrary to the intent of 40 CFR 191.12(q) and if not investigated will not allow the assessment of containment as required in 40 CFR 191.13(a). This weakens the credibility of the Site Characterization Plan. REFERENCE: Winograd, I.J. and Thordarson, W., 1975, Hydrogeologic and geochemical framework, South-Central Great Basin, Nevada-California, with special reference to the Nevada Test Site: U.S. Geological Survey Professional Paper 712-C, p. C1-C126.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-55) Table 8.3.1.2-2a	I disagree with the lower boundary condition's assigned uncertainty. Because we do not have "true" water table wells at the site the current understanding of the water table configuration is very uncertain. In addition if saturated perched water zones connect with the water table then the description of the true water table could be very complicated. The lateral boundary conditions may be more important if lateral flow is important under current or future hydrologic regimes and the need to reduce the uncertainty in their definition could be significantly higher.

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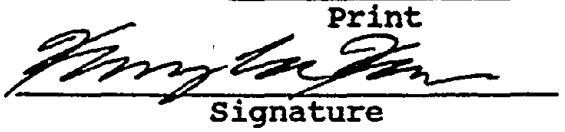

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-56) Table 8.3.1.2-2a	Another category should be included that states that Darcy's law is applicable to the matrix of the geologic units, whereas non-linear (or other non-Darcian) flow may be important in fracture flow. Not considering alternative hypotheses is not prudent to careful site characterization.

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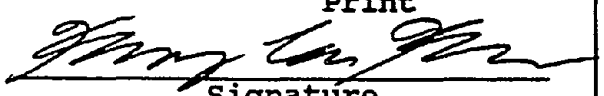

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-56) Table 8.3.1.2-2a	Concern regarding the release of radioactive gases, such as those containing Carbon-14, should raise the importance and sensitivity of the nature of gas flow.

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COMMENT NO.: 8-31 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-60) Table 8.3.1.2-2a	Regarding the current representation of perched-water bodies; it is unclear why perched water bodies are considered to be only temporary features. The sensitivity should be high. Perched water zones exist in analog sites, such as Rainier Mesa, and studies to identify these at Yucca Mountain are just beginning. The need to reduce uncertainty should be high, because the behavior of perched water bodies under present, former, and future situations is extremely important. For example, could relatively rapid growth and coalescence of smaller perched water zones, under an increased precipitation regime, rapidly change the groundwater travel time?

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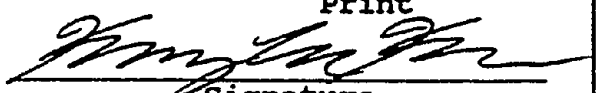

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-66) Table 8.3.1.2-2a	Evaluation of the steady-state characterization of the hydrologic system below the Paintbrush nonwelded unit is very important. If transient conditions prevail in that part of the hydrologic system, then the ground water travel time to the accessible environment could be shorter than the required 10,000 years. Thus the needed confidence in defining the system dynamics should be high not medium for this aspect.

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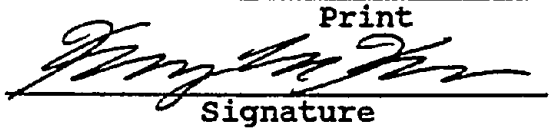

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-67) Table 8.3.1.2-2a	The SCP states that tests to date have failed to identify definitive hydrostratigraphic units in the saturated zone (8.3.1.2-89). Because similar geologic processes formed the units in the unsaturated zone, it is not clear why unsaturated zone hydrogeologic units can be defined and characterized whereas saturated zone units cannot. In reality complex geometries and hydrogeologic properties are expected in this volcaniclastic geologic setting. These may be better defined by more extensive sampling and geophysical testing and development of a depositional geologic model linked to a hydrogeologic model. This model could also have geostatistical characterization overlaid onto it. The need to reduce the uncertainty regarding the representation of the hydrogeologic properties of the unsaturated zone is at least medium, not low.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-70) Table 8.3.1.2-2b	The connection between the Tertiary units and the underlying carbonate aquifers is very poorly known. If the current representation is based only on one drillhole, then the uncertainty should be listed as being high.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-72) Table 8.3.1.2-2b	I disagree with the assessment that the uncertainty regarding the description of the water table is low. The uncertainty is higher because of the possible existence of semi-perched water zones, which could make the description of a single gently sloping water table surface difficult.

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COMMENT NO.: 8-36 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-73) Table 8.3.1.2-2b	The alternative recharge hypothesis should include: percolation following preferred fracture and fault pathways resulting in relatively rapid areally-distributed recharge.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-75) Table 8.3.1.2-2b	It is not clear that the base of the saturated system is the base of the Tertiary units. It may be necessary, especially considering the risk of radionuclide releases, to include more of the saturated geologic units, especially the Paleozoic carbonate aquifer. It has not been proven that there is no interaction between these units.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-77) Table 8.3.1.2-2b	The site hydrogeologic system should not be restricted to the controlled area, instead the boundaries should be defined based on the best available understanding of the saturated zone flow field at the time. It may be necessary to model a larger region so that boundary conditions or other aspects of the model can be better specified. For example, it may be easier to specify the upgradient boundary along a fault rather than the irregular boundary of the controlled area.

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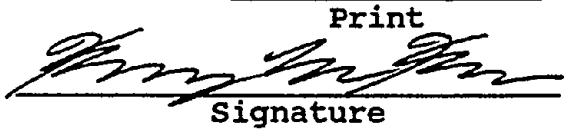

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-77) Table 8.3.1.2-2b	Our current understanding of the temporal changes of the flow field is very poor. The apparent existence of much larger water table gradients northwest of the site and our brief monitoring of the groundwater system make the uncertainty fairly high in characterizing the system geometries.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-85) Table 8.3.1.2-2b	It is questionable that "inverse modeling has been used successfully in the past to characterize ground-water flow beneath Yucca Mountain and vicinity", because extremely little good data is available to confirm or deny any model's results. The lack of true water table wells and only a crude sense of the three-dimensional distribution of heads means that past or current flow models cannot be accurately tested and determinations of success of modeling cannot be performed. The uncertainties and needs to reduce uncertainty are much higher, especially because of the complexities inherent in fractured volcaniclastic deposits.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-89 and 8.3.1.2-91)	The SCP correctly describes the present high uncertainty about fractures and their connectiveness in the saturated zone. In addition it states that definitive hydrostratigraphic units have not been identified by production surveys or hydraulic tests of the saturated zone (page 8.3.1.2-89). These statements conflict with the portrayal of the current understanding of the unsaturated zone on page 91. There it is stated: "...characterization of flow ..., for all hydrostratigraphic units." If hydrostratigraphic units cannot be adequately defined for the saturated zone, then it seems unlikely that similar rock types in the unsaturated zone can be identified, and thus modeling of the unsaturated zone becomes even more formidable. This emphasizes the need for linking a detailed study and development of a geologic depositional model for the site with a hydrogeologic model of the site. The SCP does not include plans for studies to develop a linked geologic depositional model and hydrogeologic model for the site similar to the approach proposed by Anderson (1989).

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-89 and 8.3.1.2-91)	REFERENCE: Anderson, M.P., 1989, Hydrogeologic facies models to delineate large-scale spatial trends in glacial and glaciofluvial sediments: Geological Society of America Bulletin, v. 101, p. 501-511.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-91)	Vapor movement in the unsaturated zone may increase the moisture tension in regions near fractures or faults where moisture may be channeled. Another scenario is also conceivable and should be considered. If preferred pathways for percolation exist, then depending on their geometry, the transmissive properties, the hydrologic inputs, and the presence of water at pinched zones, the gas permeability could be significantly reduced locally and moisture tensions may remain low in those regions.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1 (8.3.1.2-94)	In the northern half of the subbasin, the water table is reported to be at great depths. However, this is also the region where recharge is primarily supposed to occur in the mountainous areas. If recharge is occurring in the northern half of the subregion, as it must, then the significant thickness of the unsaturated zone by itself should not be viewed as a limitation for recharge occurring. Thus Yucca Mountain could likewise serve as a significant recharge feature depending on hydrologic inputs.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1 (8.3.1.2-96)	The studies of runoff and streamflow at Yucca Mountain probably need at least 10-20 years of detailed records to begin to assess the probabilities and characteristics of maximum floods. This may even underestimate the data needs in this environment where storm characteristics are highly variable. Streamflow studies are linked to infiltration and runoff investigations, which are essential for predicting the input of water to the unsaturated zone where the waste will be stored. Skimping on these studies and not being able to collect data over a long enough period weakens the understanding of the hydrologic system and causes concern that events of low probability but high impact may not be adequately assessed during site characterization.

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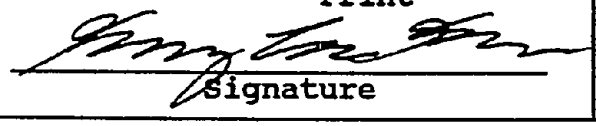

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1 (8.3.1.2-96 and 8.3.1.2-99) [8.3.1.2-6]	For a study of such importance, where accurate measurements of the inputs to the unsaturated zone hydrologic system are currently poorly known, the number and areal coverage of continuously-recording precipitation gauges should be significantly increased. Better coverage, including gauges at higher altitudes, will also prevent underestimation of the natural variability in time and space of storm rainfall. The location of the proposed rain gauges are not adequately distributed. For example, precipitation gauges are needed on the crest of Yucca Mountain, the higher northern parts of Yucca Mountain, west of the Solitario Canyon Fault, on the upland east of Beatty, and one on Timber Mountain. In general the coverage of rain gauges is adequate east and southeast of the site, but more should be continuously-recording devices.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.2.1 (8.3.1.2-104)	Because no "analog" streamflow records exist for Yucca Mountain, these data will have to be collected over a number of years. The time remaining for measuring and characterizing streamflow at Yucca Mountain prior to the license application in 1995 is too short.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.2.1 (8.3.1.2-105)	If studies are just starting to monitor the meteorological and streamflow systems in adjacent areas, there will not be enough time to measure these components prior to the license application. It is necessary to fully understand the processes acting now to make predictions for the future hydrologic system at Yucca Mountain.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.3.1 (8.3.1.2-115)	Two-dimensional, regional flow models have been developed for the Yucca Mountain area. Examples of these include Czarnecki, 1985; Rice, 1984; Czarnecki and Waddell, 1984; and Waddell, 1982. The SCP should acknowledge that work has been done in this area, and indicate if any of this previous work will be utilized in this activity. REFERENCES: Czarnecki, J.B., 1985. Simulated Effects of Increased Recharge on the Ground-Water Flow System of Yucca Mountain and Vicinity, Nevada-California, USGS-WRI-84-4344, Water-Resources Investigations Report, U.S. Geological Survey, Denver, CO. Czarnecki, J.B., and R.K. Waddell, 1984. Finite-Element Simulation of Ground-Water Flow in the Vicinity of Yucca Mountain, Nevada-California, USGS-WRI-84-4349, Water-Resources Investigations Report, U.S. Geological Survey, Denver, CO.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.3.1 (8.3.1.2-115)	REFERENCES - (continued) Rice, W.A., 1984. "Preliminary Two-Dimensional Regional Hydrologic Model of the Nevada Test Site and Vicinity", SAND83-7466, Sandia National Laboratories. Waddell, R.K., 1982. Two Dimensional, Steady-State Model of Ground-Water Flow, Nevada Test Site and Vicinity, Nevada-California, USGS-WRI-82-4085, Water-Resources Investigations Report, U.S. Geological Survey, Denver, CO.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.3.2 (8.3.1.2-118) [8.3.1.2-8]	Although the areal coverage of observation wells is quite good, it appears that another well or two are needed in Crater Flat south of WT 22. From the limited available data, it appears that flow across Southern Yucca Mountain is from west to east; thus more wells are needed southwest of the repository to better define the flow field.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.3.2 (8.3.1.2-119)	Activity 8.3.1.2.1.3.2 needs substantial modification so that "true" water table wells are constructed and monitored. These wells need to penetrate as little beneath the water table as is possible. Currently these wells penetrate 50-70 meters below the water table and thus measure a composite head over this interval, not the true water table. Packers should be installed about 2 meters beneath the current water table or below the uppermost level where sufficient fractures are located. The new wells should be drilled so that they only penetrate the water table a few meters. The measurements must be calibrated, repeatable, and the design for deep-well water level measurements should be improved. Robison et al. (1988) report numerous inconsistencies and problems that exist with the available water level measurements. REFERENCE: Robison, James H., et al, 1988, Water Levels in Periodically Measured Wells in the Yucca Mountain Area, Nevada, 1981-87: U.S.G.S. Open-File Report 88-468, 132 p.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.3.2 (8.3.1.2-122)	A very important aspect of the regional potentiometric analysis that is the foundation of that entire study is the correct design and installation of the water table wells and piezometers. The correct determination of the water table and the representative sampling of geologic units rests on the correct design of water table wells and piezometers. Technical procedures for constructing and installing water table wells and piezometers are not listed in the methods for this section and apparently do not exist. Explanation of why water table wells penetrate so far beneath the water table, which is contrary to accepted hydrologic practice, and why intervals spanning up to hundreds of meters are packed off rather than installing piezometers so that only thin intervals are sampled is not provided in the SCP. Without technical procedures, wells, which are very costly, may be installed that do not measure or sample what they are supposed to sample. This casts serious doubts about the data that has been collected by the entire saturated zone monitoring program and continues to be a major weakness. There is insufficient time before the license application to redesign

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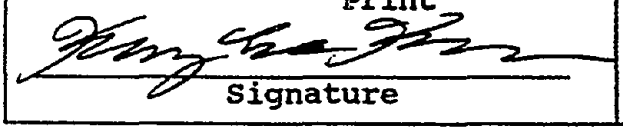

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.3.2 (8.3.1.2-122)	the study, install new wells, restart the monitoring of water level fluctuations, and collect data over a long enough period for analysis of short-term and long-term fluctuations.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.3.3 (8.3.1.2-127)	Because pulses of infiltrating water may move very quickly (order of minutes to hours if the alluvium is coarse) through the upper unsaturated zone, the use of neutron probes to monitor the moisture movement may be inadequate. Continuously-monitored soil moisture sensors should also be used in this study.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.3.4 (8.3.1.2-136)	The evapotranspiration studies appear to be well designed and should supply important answers to questions about the discharge of water. Considering the size of the playa, it may be necessary to have more than 30 piezometer and tensiometer nests. Without adequate coverage of monitoring devices and determination of areas of shallow ground water, the discharge flux for the sub-basin will be underestimated. At one or two sites, both the Bowen-ratio and Eddy-correlation techniques should be used. A thorough investigation aimed at identifying and mapping phreatophytes around Franklin Lake playa and elsewhere, for example in the Amargosa Valley, is needed.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.4.1 and 8.3.1.2.1.4.2 (8.3.1.2-137) to (8.3.1.2-144)	Although the approach of updating Waddell's 1982 regional ground water flow model is reasonable especially in terms of being efficient, it also has drawbacks. The assumptions and biases that are inherent in any model (in this case Waddell's) are perpetuated in later versions. In other words, this and future modeling efforts are constrained and may not be able to assess a full range of realistic conditions. To avoid this, one or possibly two independent modeling teams should also be assembled. Preferably, these teams will be composed of members of the international hydrogeologic community who have no experience with the Yucca Mountain site. These teams should be supplied with all of the necessary data and pertinent references for the site, but not with the details of the previous (Waddell's) model grid, boundaries, boundary conditions, parameters, etc. These teams should be well-supported and encouraged to assess a wide range of modeling scenarios. After the results are obtained, a conference should be held to evaluate and discuss the

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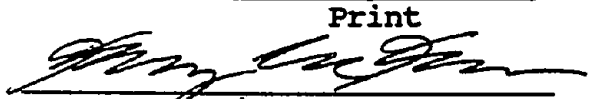
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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.4.1 and 8.3.1.2.1.4.2 (8.3.1.2-137) to (8.3.1.2-144)	differences in methods, model parameters and results, with the intent of developing an improved basis for the site hydrogeologic model and the three-dimensional model. The end result of this process would be a much more defensible assessment of the ground water flow system and travel time calculations.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.4.3 (8.3.1.2-142)	The cross-sectional modeling is a necessary component of the overall modeling effort. Unfortunately, little detailed data is available on the three-dimensional distribution of hydraulic head, especially the heads in the lower carbonate aquifer. Available data seems to indicate that flow is almost directly east across Yucca Mountain. This places the proposed cross-section line at a significant angle to the flow direction. Another problem with this activity is that the flow direction in the lower aquifer may be different than near the water table and thus selection of a cross-section line may be difficult. Validation of this model will be nearly impossible without better control on hydraulic head at depth.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.4.4 (8.3.1.2-146)	The anisotropic properties of the formations should be determined in some detail. The SCP states these are assumed to be unimportant and will be ignored. Without evaluation of the properties, how can they be assumed unimportant? It should be noted, however, that this particular model is so unrefined that specifying the units to be isotropic or anisotropic may not affect the results.

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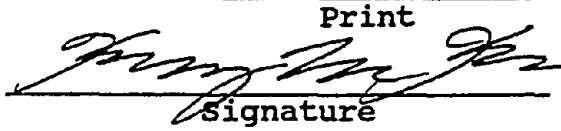

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2 (8.3.1.2-151)	DOE acknowledges in this section of the SCP how little is known regarding unsaturated flow in fractured rock environments. This situation applies to vapor-phase as well. Given the short time period allowed for Site Characterization, it cannot be realistically expected that this lack of knowledge can be overcome. Basic lab and field investigations cannot be successfully carried out until research is done on what methods might be feasible towards performing these investigations. Rigorous theoretical progress will be necessary as well in order to interpret collected data. Given the extremely long time scales that scientific research normally requires, it is unlikely that a significant amount of information can be generated during Site Characterization. It seems much wiser to consider sites where traditional porous-media flow occurs. Ground water flow in such areas has been studied successfully for decades. While such sites may or may not be inferior to Yucca Mountain, they will clearly decrease the amount of uncertainty involved in performance assessment evaluations.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2 (8.3.1.2-151)	Given the extreme hazard of high-level waste, reducing uncertainty is of the highest priority.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.1.2 (8.3.1.2-164)	It is unclear why the particular six "parameters" are listed in the fashion on page 8.3.1.2-164. While there is nothing inappropriate about such a list, neither does it appear particularly profound. These six terms relate to infiltration in one way or another. However, they do not seem to have encompassed every possible variable relevant to infiltration, nor do they seem to suggest six broad aspects of infiltration. This particular list simply confuses the reader. Such lists are ubiquitous in the SCP.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.1.2 (8.3.1.2-165)	The discussion of the neutron moisture logging study does not specify the average depths that existing and future access holes will be surveyed over, nor is it mentioned if any holes are planned to be emplaced subhorizontally. Subhorizontal boreholes would probably be preferable in monitoring fractures. It is unclear if the boreholes will or do extend into bedrock. Also, the frequency of measurements is not stated. Furthermore, a brief summary of the data gathered to date would be helpful in order to evaluate the value of this study. Most importantly, there is no discussion of exactly how the results will be used to calculate infiltration rates. It seems logical that changes in water content will be integrated over time at the various depths to calculate cumulative infiltration, however this is not stated in the SCP. Given the short duration of time for site characterization, these details need to be established immediately. Interpreting the data as it is collected will allow problems to arise at a time early enough for their mitigation. This data should not just be archived until some later time. If this latter procedure is followed, it is more and more likely that the data will never be reduced and analyzed.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.1.2 (8.3.1.2-165)	It is not stated in the SCP how many tritium samples will be analyzed in this study nor to which borehole locations they correspond. It must be realized that when dating matrix pore water in a fractured rock environment, it may be possible that younger fracture water may bypass old matrix water during precipitation events. Therefore, results of tritium analyses of matrix water must be interpreted carefully.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.1.2 (8.3.1.2-169)	As is acknowledged in the SCP, it is well established that water balance studies where the error in precipitation rate and/or evapotranspiration rate is larger than the infiltration rate, are useless. It is very likely that the prototype water balance study proposed for the USGS will reveal nothing new. In light of these observations, it would not be a good investment of time and resources to pursue this water-balance pilot study.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.1.3 (8.3.1.2-172 to 8.3.1.2-179)	The evaluation of artificial infiltration provides a rough overview of a series of four field investigations and states that: "each type of study increases in complexity and builds on the results of previous studies (p. 8.3.1.2-173). These studies, if well designed and executed, could provide significant results on the infiltration process. However, it appears unrealistic that these studies could be completed (or possibly even begun) by the time of the license application. No anticipated time line is offered for these studies, which are only roughly outlined. The technical procedures listed are incomplete and do not provide assessment of the details of these studies.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.1.3 (8.3.1.2-173)	DOE plans a series of double ring infiltration tests to be performed on the surface of Yucca Mountain in order to "characterize infiltration rates" spatially. On page 8.3.1.2-173, the SCP states, "The term infiltration rate is defined here as the infiltration flux resulting when water, at atmospheric pressure, is made freely available to the unconsolidated material surface." From this definition, and the lack of references and detail regarding the double-ring method, it appears that DOE does not adequately understand infiltration nor what the method involves. First of all, infiltration rate is not a constant. Upon introduction of a thin, ponded surface to the soil profile, the infiltration rate will be at a maximum, as time goes on this infiltration rate will decrease and approach the saturated hydraulic conductivity of the soil. Because early-time vertical hydraulic gradients can be substantially larger than

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.1.3 (8.3.1.2-173)	unity, the early infiltration rate can be significantly higher than the final value. Therefore, the definition of "infiltration rate" in the SCP is flawed because actual infiltration rates depends on the length of the test. If the test is to be conducted until the infiltration rate levels off at a minimum value, then what is truly being measured is the saturated hydraulic conductivity. It is not clear that DOE realizes this judging by the SCP.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.1.3 (8.3.1.2-174)	If the organic dye tracer test is successful and its distribution on or adjacent to fracture surfaces can be identified, it would be very beneficial to do the excavation in increments from one side to the other. Detailed mapping of the exposed vertical surface would then permit a three-dimensional assessment of the fluid paths. This would be much superior to a determination based on only one exposed surface.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.1.3 (8.3.1.2-174)	The SCP mentions several parameters and variables that are to be evaluated during the ponding experiments using a neutron moisture meter. These parameters include infiltration rate, flow velocities, matrix/fracture relationships, and unsaturated hydraulic conductivity as a function of water content. Unfortunately, only the last of these parameters include a reference in the SCP as to what method will be used to interpret and analyze the data (Libardi et. al., 1980). Unless similar references to published techniques are established, it is very unlikely the data collection activities will be successfully planned and executed. REFERENCES: Libardi, P.L., K. Riechardt, D.R. Nielsen and J.W. Biggar, 1980. "Simple Field Methods for Estimating Soil Hydraulic Conductivity", SSSAJ:44 (3-7).
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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.1.3 (8.3.1.2-175)	As is the case for much of the infiltration studies described in the SCP - there are no references made to which techniques will be used to perform these studies. The SPRS studies are expected to "determine the complex relations between rainfall, thickness and properties of unconsolidated rock or soil and the development of perched water tables" (p. 8.3.1.2-175). Because the fractured rock properties are not to be evaluated in these studies, numerous techniques are available from the soil science disciplines to undertake these studies, yet none of these are referenced. It will not be necessary, nor likely worthwhile, in this case to undertake research into these techniques given the existing level of knowledge in soil physics. It is paramount to performing the SCP activities in an efficient and timely manner that such references specifying analysis techniques and instrumentation be established immediately.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.3 (8.3.1.2-183)	The SCP states, "No natural perched water has been observed in holes drilled in Yucca Mountain. However, circulating drilling fluid that was last in hole USW G-1 was observed in USW UZ-1, 335m distant." The tone of this statement indicates that it is an established fact that the perched water is a result of the loss of drilling fluid in hole USW G-1. In Chapter 3 (p. 3-150) of the SCP it is stated, "...because the water was contaminated with drilling fluid polymer used to drill drillhole USW G-1...it was speculated that the perched-water horizon was not natural but a result of drilling drillhole USW G-1...". The first quote implies that there is no question the perched water is <u>completely</u> due to drilling fluids, while the second only speculates about this. Even if drilling polymer was found in the well water, it is possible that some of this perched water was natural and was supplemented by the drilling water. Until more evidence is revealed, it should be considered that natural perched water may have contributed to this occurrence.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.3.1 (8.3.1.2-183 thru 8.3.1.2-191)	The USGS conducted a test to determine effects of wet versus dry drilling techniques in tuff in G-Tunnel. The results of these experiments showed that drilling fluids penetrated into the removed core and replaced as much as 40% of the pore fluids. Conversely, dry drilling dried out the core somewhat. In either case, extrapolation of hydraulic or geochemical parameters from laboratory analyses of cores will not give an accurate representation of the unsaturated zone. Therefore, more pressure is placed on the in-situ field experiments to yield representative results.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.3.1 (8.3.1.2-189)	In order to most efficiently perform the testing for moisture-retention curves, relative permeability, and saturated permeability; a comprehensive literature survey is recommended to identify which of the various techniques might be most applicable to tuff. It is commonly the case that when a particular testing procedure is developed, only one soil or rock type was utilized as the tested medium. Eventually, several methods become available yet very few are applicable to the entire range of possible porous media. It would be advantageous to focus only on those techniques developed on a soil or rock with similar characteristics to tuff, rather than perhaps a coarse sand for example.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.3.1 (8.3.1.2-190 thru 8.3.1.2-191)	The SCP includes numerous references to established techniques that will be used to measure matrix hydrologic properties. Given the short duration for the Site Characterization Program - it is very possible that this phase of the program will be the only one completed. Very few of the other hydrologic investigation techniques have been established or apparently even speculated upon. DOE should have in-place, some type of fall back position in case they cannot gain any insight into fracture-flow processes at Yucca Mountain. If this occurs, little more will be known about the site than is known now and placing high-level waste at Yucca Mountain would be a highly speculative undertaking.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.3.2 (8.3.1.2-202)	Inspection of Figure 8.3.1.2-14 reveals that no vertical boreholes exist or are planned in the northern 3/4 of the perimeter drift area. An obvious concern arises in that no coverage of this large area is planned. Unless there is some overriding issue, boreholes should be installed in that area to gain an insight into the hydrologic character of that area and its subsurface.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.3.2 (8.3.1.2-207)	The SCP states that multiple test zones will be selected for each hydrogeologic unit for packer nitrogen-injection testing. As part of the Site Characterization Plan, the criteria for selection of these zones should be stated. In other words, will the sampling be planned to assure regular spacing to support statistical analyses? Or will the irregularities be focused upon in order to support worst-case scenarios that might be used to compensate for uncertainty? In any case, how these intervals will be selected should be established.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.3.2 (8.3.1.2-210)	Montazer (1986) calls into question the adequacy of the current vadose zone monitoring regarding soil-water potential due to effects from gravel packs, and silica flour columns in USW UZ-1. Planned borehole completions should be based on the results of previous monitoring in that hole. Gravel packs appear particularly burdensome in regards to monitoring matric potential. Direct contact of monitoring devices with the host rock is obviously preferable although, admittedly, not always possible. DOE's approach to this problem should be outlined in the SCP. REFERENCES: Montazer, P., 1986. "Application of Hydrologic Techniques in Characterization of Unsaturated, Fractured Rocks" AGU Fall Meeting, San Francisco, CA, 1986.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.3.2 (8.3.1.2-207, 8.3.1.2-210)	None of the descriptions of the various pneumatic (gas) and liquid-phase testing planned for the vertical boreholes and clusters include any references to fractured-rock testing techniques and data analysis methods developed for the petroleum or geothermal industries or from previous waste disposal applications. It is acknowledged that established techniques in this field are few in number. However, a starting point is needed, even for the prototype testing. These references should be established to the extent possible before further data collection activities are planned.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.3.3 (8.3.1.2-223)	The SCP states that air will be used as the drilling medium in order to preserve the ambient moisture content of the recovered core and cuttings and of the in situ rock mass. While using air is preferable to water, and is therefore the best choice, it must be realized that the introduction of air into the fractured rock mass will likely perturb the ambient conditions, most notably by lowering the relative humidity in the immediate vicinity of the borehole. It is acknowledged that such a situation is unavoidable, however the monitoring results should be interpreted with this phenomenon in mind.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.3.3 (8.3.1.2-223)	In order to collect perched or other free water in the unsaturated zone via the Solitario Canyon horizontal borehole study, delicate instrumentation will likely be necessary. The report "Characterization of Infiltration into Fractured, Welded Tuff Using a Small Borehole Data Collection Technique" by W. Linderfelt of the Desert Research Institute, University of Nevada may provide valuable information towards planning this instrumentation. In this study, infiltrating water was successfully sampled from fractures following precipitation events.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.4.1 (8.3.1.2-241)	The SCP suggests the performance of tracer tests on laboratory samples of fractured tuff in order to investigate matrix diffusion processes. In order to confidently interpret results, tracer tests should be run using two different types of tracers. One tracer should be amenable to matrix diffusion (a standard solute), and the other should be an inert, relatively large particle tracer (such as silica spheres) that will not exhibit diffusive behavior. Comparison of break-through curves of the two different tracers under equal flow conditions will reveal the possibility of matrix diffusion. Care must be taken that moisture conditions in the cores are representative of Yucca Mountain.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.4.1 (8.3.1.2-242)	An obvious omission in terms of previous studies that could be utilized in studying channelization in fractures, are those described in Neretnieks, 1985. These pioneering studies represent invaluable planning resources for the studies described in this section of the SCP. REFERENCES: Neretnieks, I., 1985. "Transport in Fractured Rocks" in Hydrogeology of Rocks of Low Permeability - Proceedings of a Symposium Tucson, AZ. January, 1985. International Association of Hydrogeologists.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.4.2 (8.3.1.2-254)	The SCP briefly describes planned tests to be conducted on core samples including fracture location and geometric parameter logging as well as hydraulic property testing of the rock matrix. The concern here is the implied ease in which this experiment is apparently expected to entail. Retrieving core long enough for instrumenting experiments can sometimes be difficult. Some of these complications should be addressed in the SCP.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.4.7 (8.3.1.2-301)	It can reasonably be expected that near saturation conditions will occur in the host rock near any seeps encountered by the exploratory shaft. The SCP states that psychrometers will be used to measure soil-moisture potential in the boreholes installed at these seeps. Unfortunately, psychrometers are not useful in measuring near-saturation soil moisture potential, but rather they can be used at pressures below -2 bars (Hillel, 1980). Use of psychrometers in the vicinity of seeps should therefore be reconsidered. REFERENCES: Hillel, D., 1980. Fundamentals of Soil Physics, 413 pp. Academy Press, New York, New York.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.5.1 (8.3.1.2-321)	The SCP states the results of the diffusion test (tracer concentrations as a function of radial distance in the host rock surrounding a borehole) will be analyzed under the assumption that fluid flow does not occur. Inasmuch as the host rock will be initially unsaturated upon introduction of the tracer solution in the borehole, it would appear that fluid flow will occur outward from the free-standing liquid in the borehole. The plans to assume no fluid flow should therefore be re-evaluated. If fluid flow is neglected as planned, it would appear that diffusivity would be over-estimated.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.9 (8.3.1.2-350)	The "plans" for modeling ground water flow and radionuclide transport in the unsaturated zone as presented in the SCP are essentially generic to any sophisticated modeling study. In other words, DOE is so far from actually performing any technically defensible modeling, that it is unlikely it will ever be done.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.9.2 (8.3.1.2-353 thru 8.3.1.2-355)	This section on selection and development of hydrologic modeling computer codes is noticeably lacking in specific references to existing codes. The SCP speaks of available codes, but none are specifically named. The selection and modification of codes to model conditions in the unsaturated zone is a complicated undertaking. The SCP should already contain a list of models under consideration if this task is expected to be completed in a timely manner.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.3 (8.3.1.2-369)	This section of the SCP discusses several of the large areas of uncertainty in performing and interpreting hydraulic stress-testing in fractured media. A "catch-22" situation exists in this area in that pre-test analyses (modeling) of the test are sometimes necessary to design the tests adequately. A conceptual model of fracture flow (e.g. channel flow, parallel plate, etc.) must be available as a basis for such a pre-test analysis. However, without pump tests and similar field investigations, it is very difficult to develop a conceptual model. DOE appears to have an appreciation for such situations as reflected in this saturated-zone section of the SCP. Unfortunately, preceding sections of the SCP regarding gas-phase "pump" tests in the unsaturated zone present the plans for these tests as if they are routine. This is hardly the case, particularly so for fractures that may contain two phases (gas and liquid). The unsaturated zone section of the SCP should be presented with the same appreciation for uncertainty as this section.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.3 (8.3.1.2-371)	The presentation in this section of the SCP does not make reference to the regional and sub-regional flow modeling section. Those modeling efforts are intended to provide technical bases (e.g. boundary conditions) for the site saturated zone modeling. Therefore, the site saturated zone modeling should occur after the regional modeling. The SCP should reflect such a chronology.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.3.1.1 (8.3.1.2-372)	The SCP suggests placing observation wells W-8 and W-9 on the opposite (west) side of the Solitario Fault from the pumping well USW-H7. While these wells may prove useful, detecting flow boundaries from pump tests are typically accomplished by having the observation well(s) on the same side of the boundary as the pumping well. A deviation from "normal" drawdown measured in the observation well would then be the indicator of the behavior of the boundary. For example, if the semi-log drawdown slope doubles, or otherwise greatly increases, a flow barrier is indicated. DOE should plan to install an additional observation well(s) between the pumping well and the fault.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.3.1.3 (8.3.1.2-385)	The SCP suggests a theoretical model describing flow in the fractured system at the site will be selected that most closely matches the behavior observed in previous pump tests. While this is a good approach, provisions should be made for the need to consider more than one theoretical model. One model may reflect some aspects better while a different theory may better support other observed behavior. In such a situation, it may be necessary to incorporate the more conservative model due to the large amount of uncertainty that will surely exist regarding fracture flow analyses.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.3.1.5 (8.3.1.2-401)	The SCP states that tracer tests will be used at the C-holes site to possibly investigate matrix diffusion. While matrix diffusion can be used to explain the behavior of the "tails" of breakthrough curves of diffusing, conservative tracers; the DOE should consider using non-diffusing tracers also. Comparing results from a diffusing tracer test repeated with a non-diffusing tracer test may provide the best evaluation of matrix diffusion.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.3.1.6 (8.3.1.2-411)	The SCP suggests a location immediately southwest of the repository block for multiple-well testing if single-well tests are determined to be inadequate. The approach is to select rocks significantly different from those of the C-holes location. Apparently, the reasoning here is to provide a range of values representative of the entire Yucca Mountain area. It may also be important to DOE to avoid drilling an abundance of drill holes in the down gradient area of the site (the southeast). On the other hand, the properties of the rocks to the southwest may be irrelevant to the performance of the site. For the purposes of performance assessment, a location immediately to the southeast would be better. In addition, completing the wells near the water table may be more useful than 300m below it, as suggested in the SCP. In the area immediately adjacent to the repository, radionuclides will more likely migrate near the water table. Whatever rationale is behind the suggested location of a second multiple well site should be clearly stated in the SCP.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.3.1.7 (8.3.1.2-417)	The SCP neglects to mention the significant amount of sorption data (mostly from laboratory batch experiments) available from previous studies. While this section does state literature reviews and consultations with experts will be undertaken as a first step, other portions of the SCP reflect a more-prepared state of knowledge within DOE. This section needs to be fortified with citations to the important, comprehensive data bases on sorption such as those mentioned by Siegal, et al (1987). REFERENCES: Siegal, M., S. Phillips, J. Leckie and W. Kelly, 1987. "Development of a Methodology for Geochemical Sensitivity Analysis for Performance Assessment" Proceedings of DOE/AECL Conference Geostatistical Sensitivity and Uncertainty Methods for Ground-Water Flow and Radionuclide Transport Modeling, San Francisco, CA, September 1987.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.3.2.3 (8.3.1.2-432)	No specifics are provided as to sample collection relating to parameter preservation. Retrieving representative samples from great depths is a difficult task. If these results are to be meaningful, sample collection methods must consider depth factors.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.3.3.2 (8.3.1.2-438)	Within a fracture flow system, large zones of highly conductive fractures may exist at a scales equal to the scale of interest (kilometers). For this reason, there simply may not be a useful representative elementary volume that can be incorporated into an equivalent porous media (EPM) model. If DOE wishes to pursue the EPM approach, it should be done parallel to other approaches that address discrete zones as well, in case the EPM method proves unworkable.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.6 (8.3.1.6-1 thru 8.3.1.6-6)	In a letter dated March 13, 1987, from DOE to Mr. Robert Loux of the Nevada Nuclear Waste Project Office, DOE states that, "Chapter 8 of the SCP contains a description of the plans for site characterization activities." DOE, however consistently uses Chapter 8 to present hypotheses established elsewhere without also presenting adequate technical data to justify the conclusions. For example, the hypothesis that erosional processes are not expected to effect waste isolation during the post closure period is repeated five times from page 8.3.1.6-1 to 8.3.1.6-6 without proper data presentation or referencing. In fact, the SCP admits a total lack of data on page 8.3.1.6-6: "...very little site-specific information is available that would allow for the quantification for the erosional processes at Yucca Mountain." This type of undocumented hypothesis presentation not only unjustly establishes conclusions in the readers' (and DOE's) mind, but also downplays the importance of the planned site characterization activities. Chapter 8 should refrain from presenting undocumented hypotheses and concentrate on future characterization needs.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.6 (8.3.1.6-2)	The SCP states that the "average maximum downwasting rate was estimated to be 2 cm/1000 years (Section 1.1)." Yet on page 8.3.1.6-6 the SCP also states "very little site-specific information is available that would allow for the quantification for erosional processes at Yucca Mountain". DOE's lack of data has led them to speculate on the downwasting rate, which may prove to be inaccurate. Many geomorphologists believe that mountains in the semiarid climates have the most rapid rates of downwasting found anywhere on earth. This is supported by Langbein and Schumm, 1958, who report areas with 15 cm/year of precipitation (as Yucca Mountain) should downwaste an average of 6 cm/1000 years. This dramatically increases the downwasting rates presented by DOE. REFERENCE(S): Langbein, W.B. and S.A. Schumm, 1958. Yield of sediment in relation to mean annual precipitation. American Geophys. Un. Trans. v. 39, pp. 1076-84.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.6.1.1.1 (8.3.1.6-10)	To place a lot of value on this study seems unwarranted at this time due to the extreme alteration of deposits which has occurred over the past several years from exploratory operations. Roads run along the top of the mountain and much leveling has occurred for drilling platform construction. Much of the area of concern has been drastically altered by man and may not be representative of pre-man conditions.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.6.2 (8.3.1.6-15)	The SCP addresses "average erosion rates in the region surrounding Yucca Mountain." If the SCP focuses research on obtaining only average regional erosion rates, the results could produce an inaccurate geomorphological scenario of the area. Erosion is not a uniform process and cannot be accurately depicted through average values. Any breach of a repository through erosion will not result from uniform downwasting but severe localized erosion. This type of scenario, not average erosion, should be the focus of the SCP's plans.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.6.2 (8.3.1.6-16)	The SCP introduces models aimed at forecasting future erosion rates relative to future climatic, tectonic and hydrologic trends. Included in these scenarios should be human effects upon erosion. Human activity as an agent in promoting erosion on and around Yucca Mountain could be profound. Foot and motor vehicle traffic tends to loosen overburden and accelerate erosion. This increased rate of erosion will be a function of the amount and type of human activity and will tend to augment the natural erosionary processes.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.6.3.1 (8.3.1.6-22 thru (8.3.1.6-23)	The emphasis of study 8.3.1.6.3.1 is to assess the component of total erosion due to tectonics. This emphasis seems misplaced. Rather the issue is if renewed tectonic activity occurs, what are the effects on repository stability and groundwater transport. Erosion effects should be a low priority endeavor, given a renewed tectonics scenario.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.12.1 (8.3.1.12-8)	The SCP states that since some of the data will only be available as several-year summaries, only general trends and averages for certain regions will be derived. The SCP does not get specific as to what these regions are and which data will be trends or averages. This should be known in advance, since independent researchers may have different needs for analysis. Affected parties should have more specific information as to what data will be generated.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.12.1 (8.3.1.12-9)	Will other population centers that may not be as large as Las Vegas have impacts calculated, such as Pahrump? The SCP should list areas where impacts will be calculated.

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COMMENT NO.: 8-101 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.12.2.1.2 (8.3.1.12-23)	The SCP states that one year's worth of hourly sequential meteorological data will be used as input to calculate x/Q values at each designated receptor. This could be problematic if the year's worth of data are not representative, i.e., a dry year or a wet year as opposed to an average year.

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COMMENT NO.: 8-102 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.16.1 (8.3.1.16-8 and (8.3.1.16-12)	To be effective, the log-Pearson approach should have a long historical record. How long a record is available in areas of concern?

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.16.1.1.1 (8.3.1.16-11)	It is usually assumed some debris will be transported during a severe flood. However, to try and quantify the amount and assess a separate damage from the debris versus the flood seems unwarranted. The DOE admits that they do not really know how to go about it yet, since no standard techniques exist. Large forests are not present which could bring a large number of trees or logs into the facility. Rather, we are asking how much sediment do we have to contend with? It would appear that a worse case should be assumed, perhaps equal to flood stage, since such a scenario may still be acceptable, thereby ending this line of analysis. It is more likely that erosion would be more prevalent rather than deposition at Yucca Mountain. It seems unlikely that hazards would be very sensitive to the amount of sediment in the flood.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.16.2.1.4 (8.3.1.16-24)	The objectives should include effects on water supplies of downstream users such as the Amargosa area which is dependent on continuing water supplies for farming.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.3.1.2 (8.3.3.1-5)	The current concept for borehole seals is that the principal seal component in the borehole will be used only in the tuffaceous beds of the Calico Hills. The remainder of the borehole may be filled with a granular material or a cementitious material as needed to control possible water inflow from the surface or gaseous movement of radionuclides from the repository. This may be a satisfactory approach, if the hydrologic system is static. However, the ground water system is dynamic and water levels could rise in the future. Therefore, tight seals should be designed and installed in the Topopah Springs unit as well.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.2 (8.3.5.2-3)	The role of affected Parties in the issue resolution strategy is largely undefined. However, it is of utmost importance that states play a role in establishing performance goals and in any modification of these goals which may occur at later stages.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.2 (8.3.5.2-10)	The SCP formulates goals that are intended to ensure reentry into the non-operational areas for the purpose of waste retrieval. These goals call for temperatures not exceeding 50°C for up to 50 years beginning after waste emplacement is initiated. These reentry goals do not correspond to another SCP goal, usability for a period of 84 years after waste emplacement is initiated. The lack of uniformity among these goals will result in a 34 year retrieval period where the shafts and drifts will be physically usable, but the severe environment will not permit reentry to commence retrieval operations. The SCP should clarify this discrepancy.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.2 (8.3.5.2-19)	The host rock is not a component of the waste package and cannot be counted on to provide shielding during the waste package removal.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.2 (8.3.5.2-19)	The SCP states "Numerous analyses of the performance and design of the transporter will be needed . . ." This is an obvious assumption. Specific requirements for operator exposure to radiation and other safety features should be listed.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.2.5 (8.3.5.2-45)	The SCP discusses the design issues of waste transport underground and unloading at the surface, but does not specifically address the vertical transport of the waste from the repository to the surface together with the accompanying weight limitations. The SCP should present the information needs of the vertical transport system.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.3 (8.3.5.3-16)	These analyses are for normal operating only. What assumptions will be made in these analyses? For example, what is a worse case scenario? Is the analysis to assume no releases from canisters? What about accidents involving dropped canisters?

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.3 (8.3.5.3-17)	The SCP states that maximum public-dose exposure will evaluate releases from routine operation of the repository and offsite facilities. DOE should also include background radiation in this determination. The combined exposure of all three components should be within applicable limits. This is the only way to truly assure total public exposure is below allowable thresholds.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.5 (8.3.5.5-18)	Question one reads: "What are credible accident sequences and their respective frequencies . . ."This statement should include credible "worst case" accidents. In order to adequately construct ventilation systems, and safeguards for workers and the public, DOE should perform its accident exposure analyses on the credible worst case scenario. The present wording allows analyses to be based on "credible accidents", which based on DOE's optimism regarding repository performance, may produce unrealistic accident exposure analyses.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.8 (8.3.5.8-8)	If one assumes a dry environment, then possibly this mechanism can be considered to be minimal. However, current models assume water influx controlled waste-package-release. The high temperature gradients between the waste package and surrounding county rock will almost certainly cause some thermal diffusion effects.

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COMMENT NO.: 8-116 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.8 (8.3.5.8-8 and 8.3.5.8-9)	To assume a very small steady state flux within the matrix only has potentially serious ramifications. It has been pointed out many times by various reviewers that reliance on diffusion into the matrix is not well founded for fractured materials such as welded tuff. While this argument may have validity in granitic or other crystalline terrains, it has not been shown valid for tuff. An effort must be made to determine fracture transport conditions. This investigation must be carried out during site characterization. An approach which tries to disprove the steady state assumption should be part of the strategy, rather than a confirmatory approach.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.8 (8.3.5.8-8 and 8.3.5.8-9)	The last paragraph on page 8 and first paragraph on page 9 make many assumptions regarding flow behavior under differing flux conditions. There are no data offered in support of these assumptions.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.8 (8.3.5.8-9)	Radionuclides are assumed to be retarded by the combined effects of sorption, diffusion into the matrix, mineral precipitation and ion exchange. Current work by AECL, presented at Waste Management '89, indicates these assumptions should be re-examined. AECL lysimeter tests indicated species which have had assumed high K_d values may move dominantly as colloids.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9 (8.3.5.9-1 thru 8.3.5.9-4)	This discussion leads one to believe that during the Site Characterization process DOE will develop a test program which will provide the data needed to select a packaging material. This is not true. DOE plans, by their own admission (ACNW meeting, January 1989), to select a material and one alternate by summer of 1989. This is prior to the commencement of Site Characterization.

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COMMENT NO.: 8-120 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9 (8.3.5.9-44)	With respect to long-term metallurgical changes during disposal, unresolved issues include strain aging in and near welds, and for the metastable austenitic stainless steels for the tuff repository, martensite may form or low temperature sensitization may occur.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9 (8.3.5.9-45)	The synergistic interaction of stress with corrosion is potentially the most catastrophic failure mode. Residual stresses arising from welding operations or from long-term phase transformation as well as stresses generated thermally or by external forces can interact with hydrogen absorbed by the metal from the cathodic partial of the corrosion process and/or from the radiolysis of water to produce embrittlement of steel, especially at or near the welds. In addition, hydrogen degradation of annealed steel has been found to occur, presumably because of the induced impurity segregation at grain boundaries. In the earlier portion of the storage life of the waste package, sufficiently high temperatures will be obtained to make hydrogen attack in steel a possibility. The formation of methane and the attendant grain boundary porosity embrittles the steel. Another synergism between stress and environment can develop when water solutions contact the metal, especially stress corrosion cracking of the austenitic steels in the presence of chlorides.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9 (8.3.5.9-45)	It has been found through noted experimentation that where, "metal temperatures are high enough to cause concentration of chlorides on the metal surface, cracking may occur even where the chloride concentration in the surrounding media is only a few parts per million" (Perry et al., 1963). This stress corrosion cracking occurs only for a specific temperature range of greater and solute concentration range. Except for copper, every alloy considered for waste package use undergoes stress corrosion cracking in some environment. It follows that each alloy must be examined in all credible solutions and temperature ranges, and if the radiation level is to be appreciable, because of relatively thin wall thickness, at the outer surface of the overpack, the effect of radiation on stress corrosion cracking should also be examined. As much understanding of this very complex failure mode should be developed to maximize life prediction ability.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9 (8.3.5.9-45)	REFERENCE: Perry, Robert H., Cecil H. Chilton, Sidney Kirkpatrick, 1963. Chemical Engineers' Handbook. McGraw-Hill, New York, NY. p. 23-3.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9 (8.3.5.9-46)	Localized corrosion can occur wherever there exist differences between one region of the overpack and another. These may be built in the metal in the form of grain boundary segregation, composition inhomogeneities or second phases, or they may result from the operating conditions in the repository. For example, temperature differences at the metal-backfill interface due to the geometry of the container and/or differences in contact conditions, differences in the chemical composition of moisture contacting different portions of overpack surface arising from the water having percolated through different minerals in the surrounding tuff differences in porosity or in degree of adherence of solid corrosion products, any of these may produce enhanced corrosion at one locality, pitting, or crevice corrosion. These effects are insidious and difficult to characterize and measure. Difficulty of prediction is compounded by the mineralogical diversity at the tuff site and by the variability of composition and of processing of

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9 (8.3.5.9-46)	the commercial alloys designated today as reference and as alternate materials. Localized corrosion in all its manifestations needs very careful study to develop sufficient understanding that predictive models can be developed. The effect of radiation on localized corrosion needs more investigation, as does the question of microbial corrosion. Even in a gamma radiation field, microbial corrosion does not have a zero probability, since it is now known that some microbes can withstand amazingly high levels of radiation.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9 (8.3.5.9-47)	Another set of problems may develop at a much later stage in the waste disposal history if it should happen that the overpack is breached by some corrosion failure mode. Then the inner container will be attacked by the corrosive environment, and since the inner container and the overpack will be in metallic contact, galvanic effects will occur to increase the anodic reactions at one metal and the cathodic reaction at the other. When the relatively thin inner container is breached, the corrosive environment will suffer a change of chemistry because the waste form will dissolve (in the case of vitrified wastes) or corrode (in the case of clad spent fuel rods). In the latter case the zirconium cladding will absorb hydrogen from the corrosion reaction and it is likely that the hydrides formed thereby will hasten the liberation of radionuclides by virtue of the stresses generated. The modified water chemistry will change the corrosion rate of the

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9 (8.3.5.9-47)	overpack and the inner container, which will affect the rate of widening of the breach, and hence the access of radionuclides to the backfill. The transport of radionuclides to the host rock will at this stage be controlled by the characteristics of the backfill after the temperature, radiation, and water intrusion history that it has undergone. It is known that steam treatment at high-temperatures can reduce the swelling capacity of bentonite and can increase its permeability. Channeling is a real possibility, whereby transport to the host rock can be considerably increased in rate.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9.1.1.4 (8.3.5.9-55)	This paragraph states that, "When possible or feasible, the analysis will be supplemented by actual stress measurements on prototype canisters." This sentence should be rephrased to indicate that actual measurements must be done as a verification of what appears to be a computer analysis. These measurements must be made on actual canisters, not just prototypes or scale models.

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COMMENT NO.: 8-125 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9.2.1.1 (8.3.5.9-68)	The near field environmental and thermal degradation modes should include the effects of microbial and radiological effects upon the waste package. It is known that certain microbes can withstand high levels of gamma radiation, so the possibility of microbial corrosion should not be ruled out. Additionally, the radiolytic generation of hydrogen, oxygen and other species due to gamma radiation may affect corrosion as well. The criteria for containment objectives should therefore include two addition items: g. Resistance to microbial corrosion h. Resistance to corrosion caused by the radiolytic generation of hydrogen, oxygen and other species.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9.3.2.4 (8.3.5.9-101)	Localized electrochemical attack occurs and progresses preferentially along the grain boundaries of an alloy, usually because the grain boundary regions contain material that is anodic to the central region of the grains. It is now generally accepted in the case of the austenitic stainless steels that some of the chromium combines with the carbon to form chromium carbide which is precipitated at the grain boundaries when the alloy is heated or cooled slowly. The rate and extent of the formation of the chromium carbide are functions of time, temperature, and carbon content. It occurs during welding in the base metal adjacent to the deposited metal. As a result of the localized impoverishment of chromium at the grain boundaries, preferential corrosion may occur at the grain boundaries in some environments. Although the SCP addresses the carbide precipitation, it should also discuss intergranular attack as a function of chromium carbide formation at the weld/base metal boundaries.

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COMMENT NO.: 8-127 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9.3.2.5 (8.3.5.9-103)	The SCP fails to identify one important hydrogen-induced degradation mechanism of the austenitic stainless steel waste package. Hydrogen may attack stainless steel when it reacts with iron carbides in the steel to form methane. This degradation mechanism is not considered corrosion and occurs most commonly under dry conditions at elevated temperatures and pressures. Resistance to this type of degradation increases with chromium concentration because of the greater stability of chromium carbides. The SCP should discuss hydrogen induced methane production and its effects upon the waste package.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9.3.2.7 (8.3.5.9-106)	The SCP states on pages 8.3.5.9-106, "The concentration of oxygen, nitrate and other oxidizing species is expected to influence the critical chloride level for crack initiation." The SCP should also address the sources of oxidizing species, since some will be native to the near field environment and some could be generated radiolytically due to gamma radiation. Since the radiolytic generation of oxidizing species could influence the concentration of chloride, the rates of which these species are produced should be examined.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.10 (8.3.5.10-37)	The SCP states that a performance goal of the spent fuel dissolution rate will be "no more than one part in 100,000/year." This grossly contradicts the Yucca Mountain EA on page 6-373, which reports figures of five parts in 100,000/year from two separate studies. The SCP should adopt the established results of the scientific studies or present data and discussion which justifies its lower estimates.

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COMMENT NO.: 8-130 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.10.2.1.2 (8.3.5.10-46)	The SCP references various sources such as Einziger (1985) and Smith (1985) without adequately documenting the citation. The SCP should provide complete citations of all references at a convenient location for the reader.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.10.2.2.1 (8.3.5.10-52)	The SCP reports that, "Water dripping onto and off glass" is an example of radionuclide release. The SCP tends to concentrate on the chemical degradation of the waste form by leaching water, however, and fails to mention an important mode of degradation mechanical erosion. The consistent dripping of water upon a breached waste canister will have a definite mechanical, as well as chemical erosionary effect upon the waste form. This mechanism should be included in the leach testing.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-3)	Should not fastest pathway include water vapor movement?

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-3)	How will vapor flux be considered in determining liquid travel time? Needs an explanation.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-6)	By assigning a designation "Barrier" to establish a defense in depth approach is really meaningless if fracture flow is the dominant mechanism. Currently, flow times can be shown to be a few years to a million years depending upon assumptions such as percent of flow in fractures vs. matrix. It is unlikely we will know the answers to key questions in the time allocated for Site Characterization.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-6)	The DOE strategy states, "If any combination of a single unit and set of processes could be shown to meet the goal of 1,000 years, the issue will be considered resolved." This is on the surface a logical statement and if all affected parties are in agreement on the assumptions used in the analysis, it would be reasonable. However, it should be pointed out that this will probably become a major issue. First of all, the testing proposed for the unsaturated zone is on an accelerated schedule. It is very likely that all information needs will not be satisfied to an acceptable degree of uncertainty. Herein lies the problem, DOE probably will not know the degree to which various processes operate and contribute to the velocity term. Instead, DOE will probably assert that matrix flow is the only feasible flow regime in the unsaturated zone. This will lead to the conclusion that the Topopah Spring member itself will meet the GWTT criteria, and therefore the issue is resolved. Affected

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-6)	parties, however, may argue that the data do not conclusively indicate that fracture flow is insignificant, which would argue against the issue being resolved. Without substantial guarantees laid out in the IRS for state technical issue resolution, such situations will become commonplace.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-7) [8.3.5.12-3]	DOE intends to estimate relative probabilities for alternative conceptual models. It is likely these probabilities will be nothing but guesses, highly skewed toward matrix flow. Process for assigning probabilities needs to be examined as to who will be allowed to participate in assigning values.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-10)	Darcian flow assumptions for substantial continuous fracture flow must be evaluated. It may not be valid to make these assumptions now.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-13)	The fastest ground water flow path may be interpreted as being present at the northeast corner of the current facility design since the vitric unit of the Calico Hills tuff is thin or absent in this area. This has prompted the DOE to consider relocating the current repository design position, to avoid this area. This appears to be a good move, but more data regarding what this does to size, loadings, and proximity to faults would be required before the State could agree with such a move.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-13)	The SCP states that because of uncertainty, "...flow from the entire disturbed zone boundary over the entire site may be included in the distribution of travel time relevant to this issue." This approach is inconsistent with the intent of the Ground Water Travel Time requirement specifying the "fastest path" of likely radionuclide travel. By including the entire disturbed zone as a starting point, the cumulative distribution function (CDF) for travel time would be inappropriately skewed to the large travel times. The CDF should only be based on the "fastest path" as determined from Site Characterization.

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COMMENT NO.: 8-140 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-14) [8.3.5.12-5]	Isochron maps of travel times do not account for ranges which are possible under current data. Ranges should be shown.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-17)	The SCP states that the effects of matrix diffusion (between the fractures and the matrix) will be considered in the Ground Water Travel Time calculation. It should be realized that matrix diffusion processes may be very difficult to support technically as is stated by the U.S. NRC in the following quote: "The mechanisms of matrix diffusion are difficult to evaluate in the field. Without direct measurements of the appropriate coefficients, estimates of the effect of matrix diffusion would have to be based on mathematical models which are largely untested, using parameters which are difficult or impossible to substantiate" (Codell, 1986). Furthermore, the Site Characterization program is only allowed a relatively short time for its completion. As described in the SCP (Chapter 8.3.1.2 - Geohydrology), the planned activities do not even include references to using non-diffusing tracers in comparison with diffusing tracers to investigate the

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-17)	possibility of matrix diffusion. In other words, the planned site characterization investigations do not appear to be adequate in order to support reliance on a process the NRC has stated may be virtually impossible to substantiate. REFERENCE(S): Codell, R., 1986. "Draft Generic Technical Position on Ground Water Travel Time" U.S. Nuclear Regulatory Commission, Division of Waste Management. June, 1986.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-20)	It cannot be said that the current estimate of flux is conservative. Quite the opposite - it is not conservative. Valid ranges for flux and effective porosity have not been established. Effective porosities for welded units appear very high.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12.1 (8.3.5.12-28 thru 8.3.5.12-33) Table 8.3.5.12-3	The desired levels of confidence for the fracture properties would appear to be ranked too low given the importance of determining the extent of fracture flow occurring at the site. If significant recharge is occurring through the unsaturated zone at Yucca Mountain, it is probably occurring via transient, fracture flow episodes. The isolation capabilities of the site are heavily based on the assumption that very little recharge occurs through the unsaturated zone. This assumption would appear to hold if only matrix flow is occurring due to the low hydraulic conductivity of the tuff matrix. However, it is not known if fracture flow occurs. Therefore, determining the fracture flow parameters in Table 8.3.5.12.3 should be given "high" priority.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-39)	Not all sparsely sampled parameters will be corrected to more densely sampled ones. Leaving the true range up for grabs. This range will undoubtedly be assigned a value based on "expert judgement", which may be heavily biased.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-41)	Reference is made to several models which are being developed to generate unsaturated porous-media properties from detailed structural and physical concepts. Detailed references should be provided, i.e. whose doing the work, its funding source and its status.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12.2 (8.3.5.12-42)	It would appear the composite medium approach of Klavetter and Peters (1986) may be appropriate for steady-state simulations but not for transient cases, especially so for unsaturated flow. As part of the SCP, the DOE should consider what approach will be taken if better models do not become available. REFERENCE(S): Klavetter, E.A. and R.R. Peters, 1986. "Fluid Flow in a Fractured Rock Mass". SAND85-0855 Sandia National Laboratories for the U.S. DOE.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-42)	Limiting the travel time studies to only equivalent porous media approaches is not conservative. We recognize that DOE and USGS want to believe flow is matrix dominated. However, the jury is not in yet, so dual porosity approaches should not be prematurely ruled out based on DOE's "current beliefs".

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COMMENT NO.: 8-148 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-43)	Simplifications may be required in overall performance assessments. When they occur, they must be backed by thorough knowledge of the processes being simplified. To eliminate pressure terms, assume flux and divide this flux by moisture content to get velocity is premature in light of our rudimentary understanding of the processes.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12.2 (8.3.5.12-43)	It should be realized by the DOE that the Wang and Narasimhan simulations were only successful for steady-state or near steady-state flow <u>across</u> fractures at low levels of saturation. Flow <u>along</u> fractures was not simulated adequately. A substantial amount of work needs to be done regarding transient flow conditions in fractures in the presence of partially-saturated matrix, before conclusions can be made regarding infiltration through the unsaturated zone at Yucca Mountain. REFERENCE: Wang, J.S.Y. and T.N. Narasimhan, 1985. "Hydrologic Mechanisms Governing Fluid Flow in Partially Saturated, Fractured, Porous Tuff at Yucca Mountain." SAND84-7202 Sandia National Laboratories for the U.S. Department of Energy. Wang, J.S.Y. and T.N. Narasimhan, 1986. "Hydrologic Mechanisms Governing Partially Saturated Fluid Flow in Fractured Welded Units and Porous Non-Welded Units at Yucca Mountain." SAND85-7114 Sandia National Laboratories.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12.2.1.1 (8.3.5.12-45)	The fact that development of a mathematical representation of flow at the site has not yet been adequately accomplished, indicates the rudimentary understanding of ground water flow at the site on the part of the DOE. To provide reasonable assurance, as required by the U.S. NRC regarding issues such as satisfying the ground water travel time requirement at Yucca Mountain, will require a much longer period of time for site characterization than is allowed for in the current schedule. Because of the complexity of fluid flow and energy transport processes in unsaturated rocks makes quantitative studies more difficult and less certain than for some other media, the relative favorability of Yucca Mountain as a repository location must be considered diminished.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12.2.2.2 (8.3.5.12-46)	This section is entitled 8.3.5.12.2.2.2 Subactivity 1.6.2.2.2: Validation of Models. This section is misrepresentation at best, and is misguided. Misrepresentation of what is to occur is serious in and of itself. The title leads one to believe that model validation procedures will be laid out. However, after reading the section, validation will not be done and is so stated in the first full paragraph of page 8.3.5.12-48. Further, the work described is calibration, not validation. It is designed to allow model calibration of parameters as needed to match a single core sample imbibition experiment. First, DOE must try to validate models of physical processes we are trying to simulate. Of major concern is whether or not fracture flow dominates in the unsaturated zone. This is what is needed to assess the validity of travel time distributions.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12.2.2.2 (8.3.5.12-46)	It does not appear useful to use a matrix-flow type of imbibition experiment to arrive at "validated" input parameters for travel time calculations. This is because the main question is assumed answered, i.e. you have matrix flow only. This section should be deleted or redone to specify calibration not validation. A true validation procedure must also be developed.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12.2.2.2 (8.3.5.12-49)	Paths of likely radionuclide travel are to be determined directly and by modeling. The focus is obviously on the modeling. This emphasis should be changed to include more direct observation. The examples cited do not indicate if these observations are to take place underground in the shaft or drifts. The discussion, in fact, leads one to believe this will not be done in situ, since the following statement appears: "This evaluation will involve examination of what is known about the features at the site." Only when shafts and lateral drifts are completed and reach an equilibrium conditions will many of the flow paths be discovered.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-51)	A two-dimensional approximation for the saturated zone if the ground water travel time is the only concern. However, for an overall performance assessment and to address Szymanski's concerns, a three-dimensional model will need to be developed.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-55)	This limited definition, i.e. changes in intrinsic permeability, is troublesome. The regulation requires the evaluation of effects caused by thermal output of waste. This thermal envelope may affect the rock and water to depths greater than 50 meters. Consequently, changes in hydraulic conductivity need to be evaluated because of thermal changes to water density and viscosity. Do not limit change to intrinsic permeability, include the water as well as the media.

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DATE: June 29, 1989

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 8-155 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12.5 (8.3.5.12-56)	Pages 8.3.5.12-40 thru 44 discusses models to be used to predict groundwater travel times between the disturbed zone and the accessible environment for the purpose of determining pre-waste-emplacement of groundwater travel time. It appears DOE will only be using a matrix flow code to assess groundwater travel time instead of the dual porosity (special case) code as described earlier (Klavetter and Peters, 1986). This calculation should be done using both methods to determine the more conservative approach.

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COMMENT NO.: 8-156 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12.5 (8.3.5.12-57)	The SCP suggests that at Yucca Mountain, the boundary of the disturbed zone will be much less than 50m from the edge of the underground opening. It is clear from this section of the SCP that this assertion is based only on stress-redistribution calculations. It does not take into account thermochemical processes such as hydration/dehydration, phase change, and dissolution of geologic material. Such processes are likely to be important in an unsaturated flow system such as that at Yucca Mountain.

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COMMENT NO.: 8-157 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.4.12-58)	Thermal hydrologic properties needs to be added to the list of processes considered in determining the boundary of the disturbed zone. Not just matrix properties, but fluid properties as well.

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COMMENT NO.: 8-158 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-58)	We object to the approach used to determine the disturbed zone because: (1) it considers only matrix flow and (2) it considers only media properties, not fluid properties.

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COMMENT NO.: 8-159 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-61)	Item #15 and #16 indicate that perhaps hydraulic conductivity will be assessed. If this is the case, the word permeability should be replaced with hydraulic conductivity and the word intrinsic permeability changed as well in the previous discussion.

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COMMENT NO.: 8-160 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-65 thru 8.3.5.12-68) Table [8.3.5.12-6]	Major events and planned completion dates for activities in Issue 1.6 (Ground Water Travel Time). The ground water travel time (GWTT) and pathways analysis will take place largely without any underground testing (shaft). This table indicates that validation of models will largely occur from lab studies. Identifications of flow paths will be a computer exercise calculation of pre-emplacement GWTT will be from interim Site Characterization data based on information available as of 7/91. (Keep in mind the shaft will be down by 2/91, an optimistic estimate.) Complete updating of calculations of pre-emplacement GWTT will occur 9/93 and post-emplacement GWTT on 9/92.

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COMMENT NO.: 8-161 p. 1 of 2 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.13 (8.3.5.13-55) Table [8.3.5.13-3]	Rapid fracture flow should be used as a means for partial failure of the unsaturated zone barriers (supercategory (C)). Investigations to date regarding the unsaturated zone at Yucca Mountain have not established whether periods of rapid, fracture flow occur as a recharge mechanism. Downward water velocities in excess of 60 meters/year were calculated by Tyler (1986) based on the work of Clebsch (1961) at Rainier Mesa, also on the Nevada Test Site. Tyler (1986) concludes: "... a large number of studies have indicated that soil water movement in the alluvial valleys of the NTS and surrounding areas receiving periodic inundation. Studies in fractured rock environments, although far less in number, indicate the potential for rapid fluid migration is high. Human activities requiring isolation from the underlying groundwater system should be designed with this data in mind."

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COMMENT NO.: 8-161 p. 2 of 2 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.13 (8.3.5.13-55) Table [8.3.5.13-3]	Based on studies such as Tyler (1986) and Clebsch (1961), and the lack of understanding regarding fracture flow at the Nevada Test Site, episodic fracture flow through the unsaturated zone should be considered to have a probability of greater than 0.1. Therefore, it should be an anticipated process in performance assessments at Yucca Mountain until conclusive evidence indicating otherwise becomes available. At this point, such evidence has clearly not been established. This scenario is different, although the consequences may be similar, from an "altered" hydrogeologic system when, for example, a wetter climate is assumed to exist.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.13 (8.3.5.13-73)	The SCP states "In those cases where the calculation proves difficult or time consuming, t_p may conservatively be set to zero." While this is reasonable, care must be taken that a large number of parameters are not set this way. This would decrease the validity of the model, leaving it open to criticism of being overly conservative. DOE should clarify "difficult or time consuming" to avoid using this statement as an default loophole.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.13 (8.3.5.13-75) Table [8.3.5.13-18]	It is not clear how these scenarios can be lumped or described by one model when different processes come into play. Many simplifying assumptions will have to be made to assess effects of faulting or tectonic movements on groundwater flow fields, etc.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.15 (8.3.5.15-6)	The SCP assigns a medium level of confidence that contamination from the emplaced waste will not impact the three site aquifers in 1000 years. The current understanding of fluid flow in the unsaturated zone does not warrant "medium" confidence. Rapid rate fracture flow remains a possibility and a recent report by Jerry Szymanski of the DOE raises further uncertainties on isolation abilities of the unsaturated zone. REFERENCE: Szymanski, Jerry, 1987. "Conceptual Considerations of the Death Valley Groundwater System with Special Emphasis on the Adequacy of This System to Accommodate the High-Level Nuclear Waste Repository". U.S. DOE, Nevada Operations Office.

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COMMENT NO.: 8-165 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.15.1.1 (8.3.5.15-7)	The description given for activities in this section are not complete. The SCP states parameters will be extracted from other investigations and analyzed. No mention is given as to how much data will be synthesized or even how this will be accomplished. It appears the DOE is not sure of how to proceed in satisfying regulatory requirements of 40 CFR 191.16.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.20.2 (8.3.5.20-2)	The SCP states that performance assessment models will be validated (establishing that the code and parameters adequately represent the site) and an explanation of these activities will be provided during licensing. Whereas it would be highly desirable for all codes to be validated, more realistically this validation stage will not be realized for the vast majority unsaturated zone flow and transport codes. This is due to the complexity that the dual porosity tuff media (fractures and matrix), coupled with unsaturated conditions in an arid environment with episodic precipitation, presents. Furthermore, it is not evident that the Site Characterization program can obtain the necessary input parameters. The vast majority of the planned site characterization tests are novel, and do not even have an established technique(s) to be implemented. In light of this, numerical simulation of ground water and gaseous phase flow and accompanying radionuclide transport in unsaturated, fractured tuff under

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.20.2 (8.3.5.20-2)	non-isothermal conditions will remain largely a guess. This is particularly true given the short duration allowed in the Nuclear Waste Policy Act for data collection and modelling.

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STATE OF NEVADA
NUCLEAR WASTE PROJECT OFFICE

REVIEW AND COMMENT ON THE U.S. DEPARTMENT OF ENERGY'S SITE CHARACTERIZATION PLAN FOR YUCCA MOUNTAIN, NEVADA

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Released June, 1989

REVIEW AND COMMENT ON THE U.S. DEPARTMENT OF ENERGY'S SITE CHARACTERIZATION PLAN FOR YUCCA MOUNTAIN, NEVADA

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JUNE, 1989

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ABSTRACT

This review and comment on the Site Characterization Plan (SCP) for Yucca Mountain, Nevada, as prepared by the U.S. Department of Energy (DOE), was conducted in accordance with the State of Nevada's technical oversight responsibilities as established in the Nuclear Waste Policy Act of 1982. The review itself was conducted over several months by various engineers and geoscientists experienced in such design and research endeavors.

The SCP itself was found to be very comprehensive and covered a wide spectrum of information that describes many of the proposed activities at the site during characterization. Unfortunately, many of the underlying assumptions made within the SCP that establish much of the predicted performances of the testing programs proposed may prove to be unfounded at this relatively early stage of site assessment. At this point, insufficient site-specific data exist to adequately determine the complete appropriateness and adequacy of the plans and work efforts proposed during the site characterization investigations. As such, much speculation is given to the reasonableness of the tasks proposed as a result of the lack of sufficient data. At this point in the program, both the preparers and reviewers of the SCP can only postulate expected performance.

Many of the site characterization activities will revolve around the Exploratory Shaft Facility which is the chief mechanism by which site-specific data will be obtained relating to the geologic conditions of the proposed repository horizon and the overlying formations. Of primary concern is that the proposed time frame or schedule for the testing activities is far too short to adequately assess many of the basic site characteristics. Many of the tests proposed will require an extremely long period of time to achieve accurate and reliable results. Since this required time does not exist within the program, grave concern is given to the overall success of the proposed testing activities.

From an engineering standpoint, the activities proposed during characterization were reviewed in conjunction with the proposed conceptual designs and layouts.

Many potential negative ramifications, such as those related to an increased seismic event, are discussed herein. Much evidence suggests that the Yucca Mountain site has already been determined adequate in terms of site characteristics for a deep underground geologic repository. It appears that much of the SCP was prepared to support a previously established conclusion that the Yucca Mountain site is indeed suitable for a high-level nuclear waste repository and not for the purposes of unbiasedly assessing all of the characteristics, both positive and negative, of the Yucca Mountain site as a potential host for a repository.

It is concluded that more time is needed for the complete assessment of the site characteristic behavior of the Yucca Mountain site; and, furthermore, that the testing activities should be expanded to include not only other areas on the repository block, but also a more programmatic research and testing program with sufficient time to fairly test and evaluate the overall site as a potential host for the nation's first deep geologic repository.

INTRODUCTION

This report, as prepared by H. Platt Thompson Engineering Company, Inc. (Thompson Engineering) for the State of Nevada's Nuclear Waste Project Office (NWPO), was conducted to review and comment on the Site Characterization Plan (SCP) as prepared by the U.S. Department of Energy (DOE). The reviewers of the SCP represent a varying professional background of engineering including hydrogeology, structural, mining, and civil engineering disciplines. As such, this review is primarily tailored towards the engineering considerations of the SCP. While the discussions herein cover a wide variety of subject matters, it is important that further comment and review be made on these matters to further the complete integration of all scientific disciplines into the assessment of the technical integrity of the SCP.

The review itself involved primarily the literature, data, and supporting information as provided within the SCP document; however, much referenced material was reviewed in addition to the SCP such that a better understanding of many of the discussions could be obtained. It is important to note that not every section of the SCP was reviewed in detail, as it was felt that many of the sections did not fall within the given expertise of the reviewers assigned to this project. As such, it is not the intent of the reviewers to imply that sections of the SCP are concurred with or approved as a result of no comments being made on those particular sections.

All of the reviewers were assigned various sections of the SCP for review and comment. Their comments were prepared on Technical Review Comment Forms (TRCF) for submission to the Project Manager at Thompson Engineering for compilation. To summarize the comments made by the reviewers, this report was prepared to highlight many of the comments in a concise format.

Primary concern and direction is given to aid in the ascertainment of the site characterization activities proposed within the plan to determine if the geologic setting and various parameters of the Yucca Mountain site can indeed be truly

assessed. Given the wide ranges of heterogeneity at the site, it has become very difficult to prudently assert that the true geologic condition of Yucca Mountain, Nevada, will be determined by the proposed testing activities within the SCP given time frame currently planned.

DISCUSSION

General

A tremendous amount of information within the SCP is referenced to previously published documents that are intended to support the various assumptions and conclusions made within the SCP. Without question, the whole program is in a very evolutionary state, and, as such, much of the data as presented in these previous publications appear to no longer be applicable to the discussions made within the SCP. Since much emphasis is placed on the technical integrity of these previously published documents by various research institutes, contractors, and individuals, it is important to attempt to assess the validity of the information as prepared in these documents. Within the SCP, however, much of this information is already assumed to be correct even though very little site-specific data exist from the Yucca Mountain site to accurately assert any fundamental conclusion pertaining to the characteristic geologic stability and integrity of the site.

It appears that the DOE's stance on the site characterization program is to justify the previously made conclusion that the Yucca Mountain site is adequate to host a deep geologic repository. This is rather disturbing considering that one of the primary purposes of the Site Characterization Plan is to assess the suitability of the site in an unbiased manner. The fundamental concern is that the DOE has taken an approach of a "demonstration" of suitability of the site as opposed to a "characterization" of the site for design and licensing considerations. Throughout the SCP, this philosophy pervades the discussion. Many unknowns must be answered during the site characterization phase, and many of the programs appear not to be designed so much to characterize as to demonstrate the validity of present assumptions. The eventual difficulty with this approach is that too many investigative programs are prematurely bounded by the limited assumptions that are prevalent. A true investigation and characterization would have no bounds, but would be able to respond to encountered phenomena. Many of the discussions made within the SCP reflect this commitment to the site's suitability prior to the obtainment of sufficient data that can accurately support and justify such conclusions.

The review and discussion of the SCP in this report is generally divided into two major categories with respect to waste isolation, namely 1) the natural geologic setting or barrier, and 2) the man-made or engineered barrier. From an engineering standpoint, the Yucca Mountain site is comprised of an extremely complex array of variables that must be properly assessed in order to proceed with a proper design that can benefit the waste isolation integrity of the site. Since it appears that insufficient time exists for many of the tests proposed to be conducted within the Site Characterization Plan (primarily those tests intended to assess the general nature of the physical conditions of the site), it is doubtful that every engineering parameter will be readily defined by the end of the site characterization activities. As such, the performance of any engineered facility over a reasonably long period of time cannot be accurately predicted. The result of this is the considerable emphasis that is placed on the natural geologic barriers or conditions of the Yucca Mountain site to hinder waste migration to the accessible environment. This in turn puts much emphasis on the testing programs and the research endeavors proposed to ascertain the site-specific characteristics of Yucca Mountain.

The engineering activities of the Exploratory Shaft Facility (ESF) and of a future repository is directly related to the adequacy and integrity of the data obtained as a result of the site characterization activities. Also, the post closure performance of the ESF or of a repository in turn relates to the confidence of the data obtained that is utilized in the design of all structural facilities pertaining to post closure performance, such as the seals and plugs proposed.

Hydrogeologic Considerations

The primary mechanism for waste migration to the accessible environment from a repository is water movement through the existing media. The Yucca Mountain site, without question, is an extremely diverse heterogeneous environment with varying degrees of lithophysae and fracture makeup. One of the large underlying assumptions of the SCP is that water movement at the Yucca Mountain site will predominantly occur through the rock matrix. While it may be agreed that matrix flow may be a significant part of the overall flux at Yucca Mountain, much more

emphasis should be given to fracture flow. In fact, it can be equally argued that fracture flow is the predominant flow mechanism at the Yucca Mountain site. Considering that one of the primary issues of the repository is to assess the potentially shortest time for waste migration away from the repository to the saturated zone below, it could be concluded that even if the flux at Yucca Mountain is predominantly through the matrix, the fastest path of migration could possibly be from fracture flow. As such, the emphasis on fracture flow should not be belittled as it has in the SCP.

It is stated that the water stored within the unsaturated zone is not expected to move spontaneously into the various openings that are mined at the site because such movement into large openings requires additional external energy to initiate a transient change such as increased infiltration from the surface or localized heterogeneities. Since periodic increased infiltration rates are expected, and the site, as a whole, is extremely heterogeneous, then it could logically be concluded that water will be expected to flow into the shafts, drifts, etc.

Due to the very complex nature of the Yucca Mountain site itself, the computational processes utilized in the hydrogeologic modeling of the site become a probability analysis at best. The differences between fracture permeabilities can be expressed in terms of magnitudes, and the faulted conditions of the Yucca Mountain site can amplify this differential severely. Considering that even in soils the variation between fine silts and coarse silts can be expressed in thousands of times, the fracture/faulting conductivities can exceed a variation of millions of times. As a result of this heterogeneity, the probability of developing and validating a model, within the time frame allotted for testing, that accurately assesses the true flux characteristics at Yucca Mountain is rather doubtful.

With respect to the hydrologic models being proposed to assess the matrix and fracture properties of the Yucca Mountain site, the rock matrix-hydrologic properties can be characterized by using geostatistical techniques. In the discussion of the geohydrologic models within the SCP, an application of these

techniques was not identified. Since these techniques offer some of the most powerful approaches to data analyses, it would be well to consider their application. If geostatistical techniques cannot be applied because of the lack of data, the information furnished from other models could prove to be erroneous and misleading, as the results will be less dependable.

The required detail of the site's hydrogeologic characteristic may not be able to be developed by boundary condition modeling. The emphasis within this type of modeling is on the control of the flow pattern by factors at a distance. The only value of such modeling would be to furnish a predictive vector of the regional flow at the site when modification of the regional flow occurs. This overall or regional vector, in this case, would not represent the local changes due to heterogeneity. It is extremely important that we keep in sight the fact that the local phenomenon or hydrologic characteristics are of prime concern and not some average flow rate or pattern projected across the site. In other words, much emphasis should be placed on local or near-field hydrogeologic characteristics. To accomplish this, the boundary conditions must be established from site-specific data and not from information or data that has been extrapolated across the site.

The statistical variations at this site are of a spatial nature. This requires an approach given by polygonal, inverse weighting, and least squares or kriging. Kriging is a geostatistical analysis of spatial variations. Since kriging is one of the most sophisticated approaches to geostatistical analysis and is readily available, it would appear prudent to consider this form of assessment within the analysis program. Within the SCP, it is difficult to see how Monte Carlo simulations could be applied to evaluate such factors at the site as geometric distribution of permeability, hydrologic head distribution, anisotropy of fractures, and the required detail of flow patterns. Furthermore, the geometric distribution of the standard deviation of such parameters would be required to properly ascertain the planning of test wells, boreholes, etc. Of course, perhaps one reason why kriging techniques were not employed within the SCP is because the standard deviation would be so enormous due to the heterogeneity of the site that the analysis itself would be proven not to produce the

desired results; thus, furthering the speculation of the successful development of an accurate hydrogeologic model of the site. If geostatistical techniques are not developed, the engineering design of any drainage facility, seal, plug, etc. may be based on unfounded data substantiated by foregone conclusions.

ESF, Geoengineering, and Related Activities

Given the natural setting and arid environment of the Yucca Mountain site, there is a significant amount of uncertainty involved with many of the hydrologic considerations pertaining to the site characterization activities, the ESF, and a future repository. Due to the lack of site-specific data in this region pertaining to extreme storm events, site-specific characteristics have not been thoroughly evaluated and historical information on hydrologic patterns is virtually non-existent. To further the myriad of problems involved with the hydrologic characteristics of the site, further considerations must be given to the proposed facilities constructed during the Site Characterization Plan (i.e. the ESF) that are proposed to lie within the floodways and flood plain. Many of these issues have not been adequately addressed at this stage to state conclusively that the ESF and the related underground structural networks will not be affected by a severe hydrologic event.

The flood plain limits referenced throughout the SCP and the other pertinent hydrologic information are based primarily on information and data obtained from other regions that are proposed to have similar hydrologic characteristics. Given that the ESF will be located in Coyote Wash, the flow through the existing channels in the wash must be adequately assessed such that any future impacts to the underground facilities due to either surface flooding or infiltration can be adequately ascertained at this stage. In addition to the problems associated with flooding and infiltration, the flow velocities experienced in such channels in regions similar to Yucca Mountain have illustrated the severe potential for erosion and other geomorphic impacts. Many of the facilities proposed for the ESF are located in areas where high velocities are expected, and the potential for undermining and/or erosion should always be of concern.

At this time, an accurate representation of the site's hydrologic characteristics cannot be determined, nor is it anticipated that these characteristics can be determined in the near future. This is due to the lack of historical data and to the margin of error with the empirical equations utilized in the determination and assessment of such hydrologic regimes. Until recently, historical data was not collected on the drainage patterns in the region of the ESF and across the repository site. Even with stream-flow records of up to 100 years, long-range flood predictions are difficult to establish, as the extreme variability of flood quantities in such arid climates makes accurate predictions a very speculative process.

The SCP and the referenced material pertaining to this subject matter do not attempt to mask the difficulty in accurately assessing the hydrologic characteristics of the Yucca Mountain site. Much emphasis is placed on a previous publication by the U. S. Geological Survey (USGS) as prepared by Squires and Young (1984). This study does contain several assessments of the various ravines and channels at the site and the anticipated flow rates through them. The storm event intensities themselves have been analyzed, and models have been prepared routing these storm events across the site. At this stage, with no site-specific data pertaining to the hydrologic characteristics of the site, all of the analyses before-mentioned are extremely speculative and are based primarily on judgment. Even within the Squires and Young report, it is stated that the information and conclusions as derived from their study is only a judgment of what may occur at the site from a hydrologic standpoint.

The ESF itself, as proposed in its current location, was positioned on the repository block based on a selection procedure which analyzed five particular sites on the block itself. A screening process was utilized to narrow the field of selection down to these particular five locations that were then analyzed as possible host sites for the ESF. While the selection procedure utilized which evaluated the five sites may be found adequate or inadequate, as the case may be, of major concern is the screening process which eliminated the remainder of the repository block from any analytical site selection process.

Of the five original alternative ESF sites, the current site in Coyote Wash was selected as the most suitable to host the ESF. The relationship between the location of the ESF and the hydrologic characteristics of the Yucca Mountain site is extremely interactive. The high quantities of water that will be routed through the wash in defined channels and ravines, and the resultant ponding that will occur, will certainly affect the localized infiltration rates at and around the shafts themselves. Furthermore, much of the proposed ESF is planned to be constructed within the wash which will alter the flow patterns, resulting in possible backwater effects that must be properly assessed in order to ascertain the safety of the ESF from a severe flooding and infiltration potential. To date, no such analyses of the proposed ESF has been made evident to the preparers of this report.

The proposed underground operations and testing experiments proposed within the ESF are intended to fully characterize the existing rock mass characteristics of the site as a whole. The physical factors that control the rock mass response to excavation, and then, in turn, to the thermal loading, must have some initial bounds in order to design the limits of the proposed experiments. The SCP proposes a stress field for the target horizon based on extremely limited at-depth tests in the saturated zone further away from the repository location and in fractured rock. These tests were performed using hydrologic fracturing, which does not give realistic results in fractured rock and in rock that varies greatly in terms of heterogeneity as does tuff. Many assumptions pertaining to the stress field orientation and variations have been made within the SCP which are basically unfounded. It is stated that the stress gradient is generally uniform vertically and that the usual case for the vertical stress is to exceed the horizontal stress. Both of these assumptions may prove invalid given the limited site-specific data.

Within the SCP, strength and elastic properties of the repository horizon rock units have been assigned based upon extremely limited laboratory tests and experiments. Reanalysis of these data has shown inconsistencies in the strength value for the target horizon TSw2. The ratio of elastic modulus (modulus of elasticity or Young's modulus) to uniaxial compressive strength may generally

fall within a range of 200 to 500 (Deere, 1964). Some of these data have ratios that are not consistently in this range for the TSw series of rock. Furthermore, the calculated (or derived) properties of cohesion and angle of internal friction should correlate with the laboratory-obtained strength values. The compressive strength, cohesion, and angle of internal friction are related through the Mohr-Coulomb Relationship in the following equation:

$$\sigma_c = 2c \tan (45 + \phi/2)$$

where: σ_c = Unconfined Compressive Strength

c = Cohesion

ϕ = Angle of Internal Friction

The ratio of the modulus of elasticity to the unconfined compressive strength provides an easy check on the rock mass properties utilized from various sources. The TSw series of rock does not consistently fall within the generally accepted range of this ratio, and as a result, speculation is given towards the inconsistent strength and elastic properties that are illustrated within the SCP.

The SCP admittedly states that the lithophysal-rich portions of the TSw series of rock results in wide variations in laboratory tests and in unknown variations in field tests. The lithophysae are an "inconvenient" size for incorporation into rock mass or rock matrix property evaluations. The lithophysae are longer in dimension than a drill core is wide and are much longer than most sensor anchoring or attachment points. The relevance to this subject matter is that the SCP does not provide a detailed program for investigations or demonstrations in this class of rock type.

The availability of sufficient lateral and vertical space for waste isolation and repository development is very questionable, and the SCP devotes considerable discussion to justifying the available space. Much discussion is made to the thermal area loading and the resultant impacts on expected repository performance. A rather consistent area-wide thermal load is anticipated for the repository horizon; however, the commitment to not emplace canisters in areas

where the rock conditions are not acceptable or questionable (a commitment which hopefully remains in the future) will result in localized areas of cooler temperatures which will in turn affect the overall thermal dispersion of the system. The tests planned in the ESF with respect to the thermal behavior of the rock mass are to be performed in a relatively isolated area and for a rather limited time frame. The results of these tests may not yield information and data that are truly relevant to the overall thermal system once a repository is fully in place. An area-wide, high temperature, thermal loading, as is currently expected, will result in a rock mass behavior and response different than localized heat tests can accurately predict.

The issue of thermal loading and dispersion can be directly related to the proposed retrieval operations or retrieval program as discussed in the SCP. It appears that within the SCP retrieval is apparently considered to be a simple reversal process of emplacement, and as such, no detailed investigations during the site characterization are discussed in major detail. If the canisters themselves are planned to experience temperatures greater than the boiling point of water, certainly human involvement with the retrieval process of the canisters in a fully loaded repository is very doubtful. Furthermore, mobil equipment capable of working in such an environment without the aid of constant human interaction has not been demonstrated successfully in any mining application. In essence, the problems that force the need for retrieval may in turn make retrieval itself a very difficult, if not impossible, matter.

Seismic Activity Related to Engineering Design

Much concern has been raised with respect to the maximum seismic event anticipated at Yucca Mountain being far less than what actually may occur. As a result, this discussion is made to consider the effects of a larger event on both the above and below ground structures proposed at the site.

The damage resulting from seismic activities is influenced in a number of ways by the geological site characteristics of the affected area. Where the damage is related to a gross instability of the soil and rock, the result is often represented by large permanent movements of the host environment. A somewhat

less obvious effect of soil and rock conditions on structures is the influence they exert on the intensity of ground shaking, and thereby on the structural damage which may develop even though the material underlying or surrounding a structure may remain perfectly stable during a seismic event.

During seismic activities, ground motion can occur in a random fashion in all directions. Measurements of horizontal and vertical ground accelerations, made as a function of time, have indicated that the ground acceleration contributes considerably to structural failures. When a structure is subjected to ground motions due to seismic activity, it responds in a vibratory or differential displacement fashion. For structures behaving elastically, the maximum response acceleration (defined as the maximum acceleration that a structure will experience due to a given maximum ground excitation) will depend on the structure's natural period of vibration and the magnitude of the damping present.

In engineering, a convenient way to express the combined influence of the amplitude of ground accelerations, their frequency components, and to some extent, the duration of the ground shaking on different structures is represented by means of a response spectrum. It provides the engineer with a convenient tool to evaluate the maximum anticipated lateral forces that may develop in structures subjected to a given base motion excitation.

Of particular importance to the process of generating the response spectrum are the observed maximum ordinates (defined as the maximum response values of acceleration, relative velocity, and relative displacement for a given structural system) and the fundamental period at which they occur. Thus, the frequency characteristics of the ground motions and, likewise, the form of the response spectrum may be profoundly influenced by the soil/rock conditions at the site. The frequency components of the motions at different sites and the resultant form of the response spectra change in a reasonably consistent fashion depending on the "softness" or "hardness" of the natural materials' condition.

Elements of concern for the design engineer are ground motion effects on the system, system response, prediction of system behavior, limits of acceptable

behavior, and design criteria required to ensure acceptable behavior. The objective of seismic design criteria, therefore, is to mitigate possible adverse effects of vibratory ground motion on the system of concern. In the case of the ESF and the repository's underground systems design, seismic motion may mostly result from sudden displacements along established fault patterns.

While seismic analysis and design procedures are well established for surface facilities, such is not the case for underground facilities. This may be attributed to the fact that underground facilities are regarded by many as less vulnerable to vibratory ground motion and are not generally designed for seismic loads.

An empirical approach to the design for seismic events is incorporated in most building codes. The codes used for earthquake-resistant design require that a structure of a given type be designed to withstand a static lateral force having a magnitude commensurate with the anticipated seismic motions. This is expressed as a lateral force coefficient (k) multiplied by the weight of the structure. The magnitude of the coefficient usually varies with the fundamental period of the structure, which is a function of the structure's geometrics and mass. Thus, the maximum inertia loads acting on a structure during ground motion excitation is obtained by multiplying the acceleration by the mass. This equivalent static lateral loading is normally applied with a near triangular distribution to the structure, placing the greatest load at the top. These static design loads are used in conjunction with the normal dead and live loading conditions to determine the strength of structure necessary to withstand the entire loading condition including the dynamic loads induced by the seismic event.

However, the recommended level of static-design-lateral-load is generally quite low. Dynamic analyses of structures responding elastically to ground motions recorded during severe earthquakes have shown that theoretical response inertia loads may be greater than the static-design-lateral-loads recommended by such codes. Although this difference is too large to be reconciled by safety factors in design, it is well established that structures designed to the lateral loads of codes have survived severe earthquakes. The apparent anomaly has been

attributed mainly to the ability of ductile structures to dissipate energy by postelastic deformations, helped by such factors as a reduced response due to increased damping and to ground-structure interaction. Thus, the ductility of the members is considered to be one of the most important factors in the seismic design process.

Ductility, and thus factor of safety against sudden collapse of a given structural system, is an inherent feature that is built into engineering design procedures. Since seismic design loads are accounted for in the process of arriving at an ultimate design load, the ideal design approach would be one that would introduce flexibility and energy-absorbing capacity in the system, which in return will permit the seismic displacements to take place without the prospect of generating large forces. For if a structure is designed for horizontal forces that are larger than those anticipated, it will have a greater stiffness (rigidity), resulting in a system characterized by a shorter period of vibration. The impact of a shorter period of vibration is that the structure will attract and experience more horizontal force. Thus, a structure designed for much larger forces may not necessarily be safer than a similar structure that is designed based on smaller forces. By the same token, this does not mean that a design for a smaller load is more appropriate, since this will result in a structure that is more flexible and will increase the relative displacement of the system. Therefore, provisions for ductility in the design process do not directly relate to a Design Factor of Safety, per se. The safety factor is inherent in a sense that the ductility will automatically introduce reduction in the lateral loads experienced by the structure.

As a result, in earthquake-resistant design, a primary consideration is the need to have a structure capable of deforming in a ductile manner when subjected to several cycles of lateral loading well into the inelastic range. Nonlinear dynamic analysis of code-designed structures responding to a given ground motion excitation will give an indication of the order of postelastic deformations required.

Also, as mentioned previously, determination of the effects of local ground and foundation conditions on the characteristics of earthquake ground motions is an essential part of damage prevention and analysis. It is important to make reasonable assessments of the base rock motions, especially in dealing with strong motions which are of major interest, in order to make reasonably accurate evaluations of ground motions. Analysis of the effects of ground conditions on damage due primarily to the effects of ground shaking requires an understanding of the complex interrelationships between the effects of soil/rock types, soil/rock depths, the amplitudes of ground motions, the frequency characteristics of ground motions, and the basic characteristics of structural systems in order to analyze the damage resulting from seismic events.

The general nature of the response spectrum consists of a central region of amplified response and two diminishing regions of response in which, for very-low-frequency systems, the response displacement is equal to the maximum ground displacement, and for high-frequency systems, the response acceleration is equal to the maximum ground acceleration. For very-low-frequency systems, the response for all degrees of damping approaches an asymptote corresponding to the value of the maximum ground displacement. Such a system corresponds to one having a very heavy mass and a very light spring. When the ground moves relatively rapidly, the mass does not have time to move, and, therefore, the maximum strain in the spring is precisely equal to the maximum displacement of the ground. On the other hand, for a very-high-frequency system, the spring is relatively stiff and the mass is very light. Therefore, when the ground moves, the stiff spring forces the mass to move in the same direction, and the mass must, in the process, have the same acceleration as the ground at every instant. Hence, the force in the spring is that which is required to move the mass with the same acceleration as the ground, and the maximum acceleration of the mass is precisely equal to the maximum acceleration of the ground. In general, the amplification factor for displacement is less than that for velocity, which in turn is less than that for acceleration.

In the practical field of seismic design engineering and analysis, a Design Response Spectrum is used. For any given site, estimates are made of the maximum

ground acceleration, maximum ground velocity, and maximum ground displacement, and lines representing these values are drawn on a Tripartite logarithmic chart. Representative amplification factors for 50 or 84.1 percentile (a percentile of 84.1 means that 84.1 percent of the values can be expected to fall at or below that particular amplification) are used to arrive at a design horizontal response spectrum by multiplying the motion maxima values by the amplification factors for a given damping coefficient. The amplification factors for vertical motion are usually taken as two-thirds those of horizontal.

At the Yucca Mountain site, it has been assumed that seismic motion decreases with depth. Hence, a general approach at reconciling underground seismic design to that of surface design could be arrived at by reducing the surface response spectra correspondingly, given that the depth reduction for the appropriate frequencies and the geologic conditions of the site can be accurately determined (which is speculative). The applicability and usefulness of a response spectra in the evaluation of mined underground openings, such as drifts and shafts, is questionable at this stage because the openings cannot vibrate independently, but move with the host rock. A suggested approach in applying seismic design criteria to the design of underground openings is to use the peak ground motion parameters for evaluation. It is important to note that a primary mode of failure in underground design may prove to be differential displacement. Given the heterogeneous environment at the Yucca Mountain site, this failure mode may be a controlling parameter. Peak values of acceleration, velocity, relative displacement in adjacent rocks, shear, and Rayleigh wave velocities of the surrounding rock mass can be useful in evaluating the bending strains in a stiff shaft liner, axial strain around openings, response of a shaft passing through dissimilar material, and the soil/rock dynamic loading, respectively. Thus, possible issues of concern in the design for seismic events in underground openings are ground motion damage in tunnels and shafts, potential of fault movements, and the potential of damage of shaft and borehole seals.

It can be argued that one large diameter shaft placed in a given media will move or vibrate with the adjacent ground; however, as discussed, bedded material of different composition would be expected to experience displacements that were

differential in nature. As such, nonuniform loads would be anticipated on a deep shaft through such a composite environment. Furthermore, the effects of two large shafts relatively close together would probably cause stress differentials in the shaft as the material between the two shafts would be expected to behave differently during a seismic event than the surrounding undisturbed host rock.

The effect of the magnitude of seismic events on the design of structures for seismic loading can be demonstrated by studying the response of a structure modeled as a single degree of freedom system. Assuming the system has a natural period of vibration, T = 1 second, and a damping coefficient that is five percent that of the critical damping, the maximum design ground acceleration, using the normalized Basic Design Spectrum (from N. M. Newmark and W. J. Hall), for a design earthquake with maximum ground acceleration equal to 0.40g can be computed as follows:

> From the response spectra with f = 1/T = 1.0 cps, corresponding to the curve labeled ϵ = 0.50, we obtain, after correcting for 0.40g maximum ground acceleration, the maximum design ground acceleration as follows:
>
> $$S_a = 1.3(0.40g) = 0.52g$$
>
> Following the same procedure outlined above, for a design earthquake with maximum ground acceleration equal to 0.60g, the corresponding maximum design ground acceleration equals to:
>
> $$S_a = 1.3(0.60g) = 0.78g$$

It is obvious from this exercise that an increase in magnitude of a seismic event, for a given system with constant dynamic response characteristics (i.e., natural period and damping), will result in a correspondingly proportional increase in the dynamic loading on the system since the loading is calculated based on a function of the mass of a structure times the maximum design ground acceleration. If the maximum ground acceleration, as determined for the Yucca Mountain site, is proven to be less than what actually occurs, the results could be very severe in terms of the structural failure of the facilities placed at the site as a result of the proportionally greater seismic loading.

SEALS AND PLUGS

The shafts, ramps, and drifts of the ESF, and subsequently the repository, are proposed to be sealed and plugged to aid in the post closure performance of the underground facilities. In addition, the ESF shafts are proposed to be lined with a concrete liner (12 inches thick) to further hinder water movement into and through the shafts. Although concrete designs and mixes have been used and incorporated in structures for many years, there is no precedence for such a design and application as is currently proposed within the ESF and the repository.

Seals that are utilized in relatively stable environments may prove to have a somewhat predictable life expectancy and performance behavior; however, the Yucca Mountain environment which would host the seals and plugs proposed is subject to not only inherently changing features, as is associated with a highly heterogeneous regime, but is also subject to various significant temperature changes with the associated stresses and stress migrations. In addition, stress concentrations associated with seismic loadings (discussed in another section) can create unknown and unplanned loading and boundary conditions on the seal structure which may induce vibrational resultant stresses that are undeterminable at this stage.

One of the most common and obvious situations where concrete seals have been constructed is in the application of common reinforced concrete dams. The foundations and supporting edges of the dams are forced directly into contact with prepared rock or earth surfaces. In all cases, very significant preparation of the face of the rock contact is necessary to secure an effective seal. From the testing activities proposed, it is doubtful that the behavior characteristics of the rock mass in relation to an established seal mix design will be soundly ascertained. Furthermore, even in a dam design, there is a continuing maintenance program required for all seals to maintain effective and safe performance. This is not an option (maintenance) that will be available during the post closure performance period of the ESF or of a repository.

Since concrete or cement grout is proposed for the sealing material that is to be employed within this project, certain inherent characteristics of the material must be addressed thoroughly. Although expansive cements has been proposed, the hydrothermal experiments performed to date have revealed that the ettringite, which is responsible for the expansive characteristic of the cement, was no longer present or was decreased tremendously in the cement material once exposed to high heat. This raises the questions regarding the subsequent behavior of a cement/concrete mixture, especially in terms of the shrinkage and expansive property of the mix design. Shrinkage and other characteristics of concrete seals must be assessed over a very long period of time - much longer than the time available for evaluation and performance assessment of seals during site characterization. Any shrinkage in the seal will create stresses and strains at the face of the rock at the point of contact and bond. Although completely inert or stationary conditions may not propagate failure modes within the seal, a seismic event affecting the area may certainly cause fractures within the seals along plains of weakness.

Serious concerns about the probability of sulfates in the groundwater filtering through the site are significant for not only the disintegration of the concrete, but the effects on any reinforcing steel. The progressive deterioration of concrete will also increase the porosity of the seal and compromise the overall behavior of the seal in general. The corrosion of reinforcing steel within any seal may cause significant expansion and can create stresses in the concrete as high as 4,000 psi. These stresses will, in all probability, cause further fracturing of the concrete with the result being the creation of additional pathways for waste migration.

The current design of the shaft liners for the ESF are proposed to be an unreinforced concrete section, 12 inches thick. It is not clear why no reinforcing is utilized in the seal; however, speculation is given towards the future ease of removal such that permanent seals and plugs can be placed within the shafts. The placement of such a seal without any reinforcing is in violation of the American Concrete Institute's codes on such concrete design and construction; and more importantly, the lack of any reinforcing steel can make

the seal itself extremely weak towards the resistance of any seismic event. A perfectly round shaft is an ideal structural component considering a uniform loading around its perimeter. The reason for this is relatively simple in that no moment is generated at a node around the shaft, and the faces of the liner can remain in compression. However, once a seismic event occurs at the Yucca Mountain site, the deformational behavior of the underground facilities and the resultant stress redistribution is extremely speculative. It is not anticipated that the entire structure will move as a concise unit, but rather that differential deformation will occur at various points along the shaft causing loadings that will generate tension in many of the faces of the shaft liner. These tension forces may not be resisted sufficiently by the concrete shaft seal, as concrete inherently has a relatively very low tension strength capacity (this is why reinforcing steel is utilized in reinforced concrete design).

Los Alamos National Laboratory has conducted several studies on ancient Roman ruins in an attempt to analyze the cemetitious grouts and materials utilized in the adjoining of structural stones. This information that has been gathered is very interesting and does indeed have certain applications; yet, the below ground environment at Yucca Mountain is extremely different than that previously designed for using such cementitious materials. To properly test and evaluate the performance of any seals within the ESF and a repository requires a significant amount of time to determine the effects of heat, chemical attack, and normal degradation. Since this time is not allotted for within the Site Characterization Plan, it is doubtful that any seal can be developed and designed to withstand all of the varying parameters involved for a significant design life.

CONCLUSIONS AND RECOMMENDATIONS

In conclusion of the herein discussion, it is of concern that the proposed activities to be conducted during site characterization will not adequately provide the necessary data to firmly establish the geologic setting and various associated ranges of parameters affecting the site. One of the primary reasons for this concern is that the time frame allotted for the experiments is insufficient to accurately collect the pertinent site-specific data which will aid in the assessment of the coupled processes anticipated within a repository.

The fundamental assumptions made throughout the SCP appear to route the direction of the characterization activities towards a justification of a previously-made conclusion pertaining to the site's suitability as a host site for a high-level nuclear waste repository. Given a testing program that is established based on an unbiased research endeavor to determine if the site is a suitable host site, many of the assumptions made (such as the assumptions pertaining to the rock matrix flow) may prove incorrect.

In summary, it is recommended that further investigations be made, before the ESF is constructed, towards the myriad of complex unresolved problems that plague the site, such as the impacts of extreme hydrologic and seismic events and the accurate determination of the hydrogeologic setting. Until many of these issues are resolved, the testing program will not yield sufficient reliable data to facilitate the engineering of a repository at the Yucca Mountain site that will have an accurate predictable behavior for the extremely long life proposed for the facility.

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APPENDIX (TRCF)

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 1 CHAPTER NO.: 1

SEC. NO.: 1.1 PAGE. NO.: 32 FIG./TABL:

COMMENT

The geomorphic evidence of mass wasting is declared to be an insignificant factor in the present erosional regime at Yucca Mountain. There are old slide blocks on Yucca Mountain according to the text, but the narrative does not relate these slides to the slope and the structural attitude of the rock and fracture orientations.

REVIEWER: Philip Murphy

Signature

ORGANIZATION: Dunn

DATE: 06-05-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 2 CHAPTER NO.: 1

SEC. NO.: 1.3 PAGE. NO.: 99 FIG./TABL:

COMMENT

Since the reasons for the possible location of volcanism is stated in pages 1-96 and 1-97, a better assessment of the rate of volcanic activity would be comparing the location of known centers of volcanism with locations based on the stated reasons.

REVIEWER: Philip Murphy

Philip Murphy
Signature

ORGANIZATION: Dunn

DATE: 06-05-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 3 CHAPTER NO.: 1

SEC. NO.: 1.3 PAGE. NO.: 123 FIG./TABL:

COMMENT

The table contains columns listing age of last movement and method of dating. There is no explanation on how a definite time range was determined based only on stratigraphic correlations.

REVIEWER: Philip Murphy

Philip Murphy
Signature

ORGANIZATION: Dunn

DATE: 06-05-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 4 CHAPTER NO.: 1

SEC. NO.: 1.3 PAGE. NO.: 138 FIG./TABL:

COMMENT

Ongoing and planned studies will focus on fractures exposed on surface pavements and in underground shafts and drifts to more accurately determine the extent of subsurface fracturing that may be significant to groundwater flow. Knowledge of fracture systems are also important for designing the shafts and drifts. The frequency of fractures has been observed to decrease with depth with certain layers of the Topopah Springs member being more susceptible to fracturing including the repository horizon estimated to have 34 fractures/cubic meter. The excavation of the shafts and drifts will relieve the lithostatic pressure resulting in more fractures. This possible inherent instability of the host rock must be taken into account during the design phase.

REVIEWER: Philip Murphy

Philip Murphy
Signature

ORGANIZATION: Dunn

DATE: 06-05-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 5 CHAPTER NO.: 1

SEC. NO.: 1.3 PAGE. NO.: 160 FIG./TABL:

COMMENT

If the catalog of seismic events is to be used solely for assessing seismic potential, known weapons tests and mining blasts should be deleted. However, another function of the list is to preduct any stresses the repository will experience and a basic remedial design be proposed for the exploratory shaft and drifts. Weapons tests are predictable and more of a certainty than seismic events in the next 100 years. The testing will become more important if the testing areas are moved closer to the repository as shown in Figure 1-69.

REVIEWER: Philip Murphy

Signature

ORGANIZATION: Dunn

DATE: 06-05-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 6 CHAPTER NO.: 1

SEC. NO.: 1.5 PAGE. NO.: 207 FIG./TABL:

COMMENT

The discussion comparing faulting with the unsaturated conditions of the respository concludes that the transport of radionuclides to the accessible environment is not likely in the pre-emplacement period and during the first 10,000 years. However, faulting which may occur in the post-emplacement period can change the hydrologic regime by blocking the present path of groundwater flow. The concern is not with springs appearing at the surface but with a local upwelling forming in the water table which may rise into the repository.

REVIEWER: Philip Murphy

Signature

ORGANIZATION: Dunn

DATE: 06-05-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 7 CHAPTER NO.: 1

SEC. NO.: 1.5 PAGE. NO.: 212 FIG./TABL:

COMMENT

The Yucca Mountain site is sufficiently distant from present or potential underground test locations and that collapse or fracture formation is highly unlikely. This is true in the larger sense but considering the stress regime and the possible tendency for the repository rock to fracture, these ground motions may be locally significant in the shaft and drifts by stress relieval expressed as fractures with possible failure of walls or roof. This would especially be dangerous to the crew working in an unsupported area.

REVIEWER: Philip Murphy

Philip Murphy
Signature

ORGANIZATION: Dunn

DATE: 06-05-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 8 CHAPTER NO.: 1

SEC. NO.: 1.8 PAGE. NO.: 334 FIG./TABL:

COMMENT

Details of fracture patterns at depth may not be well established for final repository design but enough is known (pages 1-135/138-Section 1.3.2.2.2) to design for the fractures already discovered during this program.

REVIEWER: Philip Murphy

Signature

ORGANIZATION: Dunn

DATE: 06-05-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 9 CHAPTER NO.: 1

SEC. NO.: 1.8 PAGE. NO.: 349 FIG./TABL:

COMMENT

An additional aspect of the investigation of fracturing should be observation of the core. If the core develops "discing," this would be an indication of how the rock would react to the open shafts and drifts.

REVIEWER: Philip Murphy

Philip Murphy
Signature

ORGANIZATION: Dunn

DATE: 06-05-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 10 CHAPTER NO.: 2

SEC. NO.: 2.0 PAGE. NO.: 2-14 FIG./TABL:

COMMENT

Rock testing samples obtained from tuff blocks obtained from outcrops have been weathered, thereby altering their properties. The use of outcrop samples for testing and extrapolation to in-situ conditions at depth needs justification.

REVIEWER: Frank Kendorski

Signature

ORGANIZATION: Dunn

DATE: 06-23-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 11 CHAPTER NO.: 2

SEC. NO.: 2.0 PAGE. NO.: 2-14 FIG./TABL:

COMMENT

Lithophysal tuff samples obtained from outcrop blocks are especially susceptible to weathering. Lithophysal tuff tested from outcrop samples may have very different properties than at depth.

REVIEWER: Frank Kendorski

Signature

ORGANIZATION: Dunn

DATE: 06-23-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 12 CHAPTER NO.: 2

SEC. NO.: 2.0 PAGE. NO.: 2-14 FIG./TABL:

COMMENT

The DOE states that lithophysae are often larger than 5.7 cm in dimension. The DOE states that since lithophysae are often larger than the 6 cm of core, larger samples will be taken from the ES. Generally, samples should be 10 times larger than the defect to incorporate the defect into the sample in a general, and not local, perturbing, way. This means that 60 cm samples, as a minimum, need to be collected. This will probably be very difficult in the ES. The blasting is likely to result in much smaller fragmentation.

REVIEWER: Frank Kendorski

Signature

ORGANIZATION: Dunn

DATE: 06-23-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 13 CHAPTER NO.: 2

SEC. NO.: 2.0 PAGE. NO.: 2-19 FIG./TABL:

COMMENT

The DOE has stepped from discussing the normal and shear behavior of fractures at large stress changes as being inelastic and non-linear to discussing general material behavior in the vicinity of underground openings where, for small stress changes, linear elastic material behavior "has been considered appropriate." The DOE has over-generalized, and over-simplified its argument here. The DOE finding is not referenced, whereas, the ones before (Goodman, 1980) and after (Zimmerman et al, 1986) are referenced. At low stress changes at low stress magnitudes, the rock mass does not behave elastically and linearly.

REVIEWER: Frank Kendorski

Signature

ORGANIZATION: Dunn

DATE: 06-23-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 14 CHAPTER NO.: 2

SEC. NO.: 2.0 PAGE. NO.: 2-19 FIG./TABL:

COMMENT

The DOE states that elastic-plastic constitutive behavior is used for the tuff materials. Actually, rock and the rock mass are plastic-elastic-plastic. The first plastic regime is uncovered at low stress levels and is a result of initial joint, fracture or flaw movements that, due to slippage, are not recoverable.

REVIEWER: Frank Kendorski

Signature

ORGANIZATION: Dunn

DATE: 06-23-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

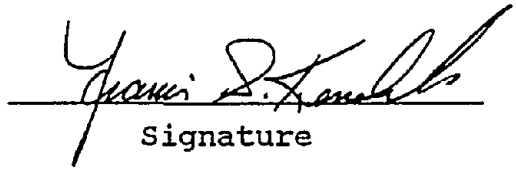
COMMENT NO.: 15 CHAPTER NO.: 2

SEC. NO.: 2.0 PAGE. NO.: 2-20 FIG./TABL:

COMMENT

The DOE states that the ubiquitous joint model is appropriate because it assumes a single ubiquitous joint set and the Yucca Mountain tuff fractures are predominantly near-vertical. There has been very little joint mapping to justify this statement, and no real-world situation resembles the ubiquitous-joint model. There are at least two steep joint sets, necessitating the realization of 3-D behavior and multiple joint sets.

REVIEWER: Frank Kendorski



Signature

ORGANIZATION: Dunn

DATE: 06-23-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Overview
DOCUMENT NO.: DOE/RW-0198 AUTHOR: DOE

COMMENT NO.: 16 CHAPTER NO.: 2

SEC. NO.: 2.1 PAGE. NO.: 11 FIG./TABL:

COMMENT

There is a possibility that groundwater may progress through the unsaturated tuff to the saturated tuff aquifer, thence, discharging into Franklin Lake Playa at Alkali Flats and may discharge at springs in Death Valley near Furnance Creek Ranch, or by evapotranspiration, contaminate Alkali Flats.

REVIEWER: H. P. Thompson

H. P. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06-14-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Overview
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 17 CHAPTER NO.: 2

SEC. NO.: 2.3.3 PAGE. NO.: 19 FIG./TABL: 2-3

COMMENT

It is stated that an important feature of the Yucca Mountain site is that its location is in the "unsaturated zone". It also states that the unsaturated zone at Yucca Mountain is thick enough to allow the construction of a repository about 660 to 1300 feet above the top of the water table. According to Figure 2-3, if the unsaturation zone is 660 to 1300 feet above the repository horizon envelope is proposed to be below the unsaturation zone. There appears to be a conflict in this information.

REVIEWER: Colleen R. Stout

Colleen Raye Stout
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-13-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 18 CHAPTER NO.: 8

SEC. NO.: 3.1.2 PAGE. NO.: 3 FIG./TABL:

COMMENT

6th Paragraph down

The data used in modeling and the computational processes become at best a probability analysis. The difference between fracture permeability runs through several magnitudes. Faulted conditions can often increase this. Fracture-faulting conductivities will exceed a variation of 10 million times. Even in soils the variation between fine silt and coarse silt is 1000 times. It would seldom be possible to determine more than one significant figure in soil permeabilities. In fracture-faulting areas at best we can only roughly ascertain the power of ten involved. This report ignores this problem. Ground water is only a carrier, however we are interested in what it is carrying in terms of velocity, sorption and dispersion as examples. Much would need to be done to evaluate these factors.

REVIEWER: H.E. Skibitzke

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: None

COMMENT NO.: 19 CHAPTER NO.: 8

SEC. NO.: 3.1.2-62 PAGE. NO.: 62 FIG./TABL: 8.3.1.2-2a

COMMENT

There appears to be no arrangement for accuracy criterion. Further there needs to be a program of sophisticated geostatistics. Geostatistical approaches specialize in furnishing the required information particularly for planning and evaluation of data.

REVIEWER: H.E. Skibitzke

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 20 CHAPTER NO.: 8

SEC. NO.: 3.1.2 PAGE. NO.: 89 FIG./TABL:

COMMENT

Second Paragraph; Less than 1% of the rainfall enters the ground. These data on rainfall would not have a sufficient figure of accuracy to apply to the problem since even the second significant figure would be in doubt.

Third Paragraph: We do not have time for an adequate sampling program.

Fourth Paragraph: Only an adequate geostatistical study could decide the drilling program, now and in the future.

Fifth Paragraph: Boundary conditions studies will tell us virtually nothing about the flow above the water table at the site. Below the water table the flow of the ground water carrier will be almost entirely controlled by heterogeneity and anistrophy.

REVIEWER: H.E. Skibitzke

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 21 CHAPTER NO.: 8

SEC. NO.: 3.1.2 PAGE. NO.: 90 FIG./TABL:

COMMENT

Unsaturated Zone- Second Paragraph. Present day rates would have to be related to long term past and long term future rates. Here we have a completely inadequate sampling period.

Third Paragraph - Let us see the design of the geostatistical analysis to determine the value of this limited series of point measurements.

Top Paragraph Page 8.3.1.2-92 - The paragraph states quite clearly the complex conditions to be encountered. Confidence intervals for the measured data will have to be determined. The relationship for modeling would require a running evaluation of this interval. The type modelling suggested here would soon be seen to have little value for engineering purposes.

REVIEWER: H.E. Skibitzke

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE-RW-199 AUTHOR: NONE

COMMENT NO.: 22 CHAPTER NO.: 8

SEC. NO.: 3.1.2 PAGE. NO.: 91 FIG./TABL:

COMMENT

Page 91- 4th Paragraph. Isotopic data would be highly desirable but the problem of mixing would have to be evaluated. This is a very heterogeneous region where mixing can be a major factor. Little data on heterogeneity is available for this area. Data not being available renders this approach indeterminate in fact, but does offer the best bet on long term predictions.

Page 92- 1st Paragraph. To make something scientifically defensible will be a difficult analysis when the mass of indeterminate data is considered. This also will present the question how long will be required to gather the required data.

REVIEWER: H.E. Skibitzke

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

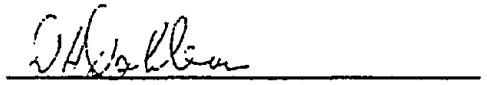
COMMENT NO.: 23 CHAPTER NO.: 8

SEC. NO.: 3.1.2. PAGE. NO.: 118 FIG./TABL:

COMMENT

Discussion in this section appears to discount the current transient state of groundwater. What is the baseline in the saturated system, and what changes are currently upstream from the repository vicinity? Then, what changes will be caused by aeration of the rock system during the mining activity? Are these changes likely to enhance downward percolation from the repository to the water table in the event of possible long term increases of water in the repository from whatever sources?

REVIEWER: DHDAHLEM



Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

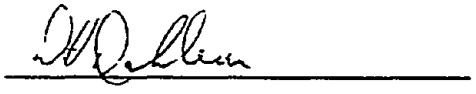
COMMENT NO.: 24 CHAPTER NO.: 8

SEC. NO.: 3.1.2. PAGE. NO.: 120 FIG./TABL:

COMMENT

The apparent uncertainty on the reason for the large potentiometric surface gradient indicates insufficient understanding of the hydrogeology to make any state on the nature of the flowpath in the saturated environment. These studies make no mention of the final data density required to provide sufficient information to answer this type of question. With no direct statement of this coupling between performance assessment and data needs, we can assume that the final data array will be sufficient to evaluate structural vagaries and to evaluate impact on the estimation of travel-time.

REVIEWER: D.H. DAHLEM



Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE-RW-199 AUTHOR: NONE

COMMENT NO.: 25 CHAPTER NO.: 8

SEC. NO.: 3.1.2. PAGE. NO.: 126-27FIG./TABL:

COMMENT

Infiltration along Fortymile Wash may be very important in the regional groundwater recharge picture. I see no estimate on how sensitive the potentiometric surface fluctuation is to amount of recharge of infiltration. I cannot determine if the study in Fortymile Wash can yeild useful information other than a nice study to collect interesting information.

REVIEWER: D.H. DAHLEM

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 26 CHAPTER NO.: 8

SEC. NO.: 3.1.2. PAGE. NO.: 134 FIG./TABL:

COMMENT

It appears that Landsat imagery may aid in phreatophyte mapping and therefore help correlate these data with structural features.

REVIEWER: D.H. DAHLEM

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 27 CHAPTER NO.: 8

SEC. NO.: 3.1.2. PAGE. NO.: 161 FIG./TABL:

COMMENT

Geotomography probably cannot help describe the fracture network and structural interfaces with enough precision to understand structural control of the hydrogeologic system.

REVIEWER: D.H. DAHLEM

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 28 CHAPTER NO.: 8

SEC. NO.: 3.1.2. PAGE. NO.: 169 FIG./TABL:

COMMENT

Natural rainfall variation may be significant. The tendency of averag- ing precipitation in desert regions over the year does not give adequate credit to the fact that the precipitation is strongly episodic. A few, very significant and infrequent storms account for all the precipitation, creating ponding, greater infiltration, and surface abundance of water not expected from yearly average rainfall.

REVIEWER: D.H. DAHLEM

D H Dahlem

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 29 CHAPTER NO.: 8

SEC. NO.: 3.1.2. PAGE. NO.: 200 FIG./TABL:

COMMENT

Normal heterogeneity in the rock system may locally affect hydraulic properties such that estimates based on test plots and not specifically at the repository may be poor estimates.

REVIEWER: D.H. DAHLEM

D.H. Dahlem

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 30 CHAPTER NO.: 8

SEC. NO.: 3.1.2. PAGE. NO.: 221 FIG./TABL:

COMMENT

Fault systems such as the Solitario Canyon structure are large scale features and may have different hydraulic characteristics from point to point on its' surface. These data collected at one location may have little bearing as an estimate or characterization of response. For instance, as the amount of brecciation changes along its' surface, the potential for change in hydraulic properties changes. As the attitude of the fault surface changes, the condition of stress across the fault changes and so also does the character of hydraulic isolation or conductance.

REVIEWER: D.H. DAHLEM

D.H. Dahlem

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 31 CHAPTER NO.: 8

SEC. NO.: 3.1.2. PAGE. NO.: 316 FIG./TABL:

COMMENT

Visual inspection may not be a sufficient indicator of the potential for perched water. The recent historical precipitation may be abnormal and recent structural condition may be abnormal.

REVIEWER: D.H. Dahlem

D H Dahlem

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 32 CHAPTER NO.: 8

SEC. NO.: 3.1.2. PAGE. NO.: 316 FIG./TABL:

COMMENT

Because the system is unsaturated, there may be no way to test the hydraulic properties of large-scale features like a fault in situ. With fault integrity potentially changing in time according to tectonism, this activity may be useless.

REVIEWER: D.H. Dahlem

D.H. Dahlem

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 33 CHAPTER NO.: 8

SEC. NO.: 3.1.2. PAGE. NO.: 351 FIG./TABL:

COMMENT

Apparently there is no feedback loop from modeling driving the amount or nature of data collection. Is performance of the system sensitive to the hydraulic parameters of the unsaturated zone system? If so, what parameters, and are they directly measured in these experiments? What are the acceptable ranges for data?

Testing program may be very complex and costly and yet not answer the question.

REVIEWER: D.H. Dahlem

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP REview
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 34 CHAPTER NO.: 8

SEC. NO.: 3.1.2. PAGE. NO.: 353 FIG./TABL:

COMMENT

TBD's in the area of defining the codes, test methods, review and control (configuration) are not giving confidence the program has decided on a specific direction. How can the public review the worth of this work?

REVIEWER: D.H. Dahlem

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 35 CHAPTER NO.: 8

SEC. NO.: 3.1.2. PAGE. NO.: 359 FIG./TABL:

COMMENT

I see no estimate of acceptability in this section. Given some experience with data and evaluation methods, what are your estimates of uncertainty? What is tolerable?

REVIEWER: D.H. Dahlem

D.H. Dahlem

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

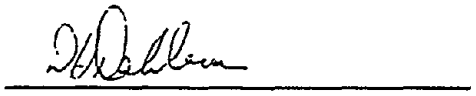
COMMENT NO.: 36 CHAPTER NO.: 8

SEC. NO.: 3.1.2. PAGE. NO.: 366 FIG./TABL:

COMMENT

With such a flat water table, how long will it take to provide a baseline. I don't see this addressed as a critical item such as at Hanford.

REVIEWER: D.H. Dahlem



Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 37 CHAPTER NO.: 8

SEC. NO.: 3.1.2. PAGE. NO.: 367 FIG./TABL:

COMMENT

With such a low gradient down-gradient from the repository, how do you know the direction of flow. Is the downward migration along deep flow paths that would transport radionuclides into deep circulation cells and away from the repository area.

REVIEWER: D.H. Dahlem

D H Dahlem

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 38 CHAPTER NO.: 8

SEC. NO.: 3.1.2. PAGE. NO.: 369 FIG./TABL:

COMMENT

The fracture network beneath the repository will dominate liquid and radionuclide transport. The only viable way to assess this transport is by in situ testing, requiring boreholes. These boreholes will require seals which must remain active for 10,000 years, beyond current experience. How can you assess this system with sufficient precision and not cause a leaky environment?

REVIEWER: D.H. Dahlem

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 39 CHAPTER NO.: 8

SEC. NO.: 3.1.2. PAGE. NO.: 441 FIG./TABL:

COMMENT

How will you show that pathways conceptualized for groundwater and radionuclide transport are actually appropriate for the geosphere containing the respository?

REVIEWER: D.H. Dahlem

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 40 CHAPTER NO.: 8

SEC. NO.: 3.1.2. PAGE. NO.: 441 FIG./TABL:

COMMENT

How will you show radionuclide flux transported; given that equilibrium partitioning into the fluid and between fluid and rocks will vary with time, chemistry, temperature, pressure?

REVIEWER: D.H. Dahlem

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 41 CHAPTER NO.: 8

SEC. NO.: 3.1.2-2a PAGE. NO.: 6 FIG./TABL: 8.3.1.2-2a

COMMENT

Data reduction models

Line 1
The rock matrix-hydrologic properties can be characterized by using classical statistical and geostatistical techniques as stated. We are unable to find application of these techniques (eg Kriging) to these problems. Since these offer the most powerful approach to data analysis it would be well to consider them. If geostatistical techniques cannot be applied, then anything else would do less and could furnish misleading information.

REVIEWER: H.E. Skibitzke

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 42 CHAPTER NO.: 8

SEC. NO.: 3.1.2-2b PAGE. NO.: 68 FIG./TABL: 8.3.1.2-2b

COMMENT

Table 8.3.1.2-2b encompasses virtually the entire field of groundwater hydrology. If this is a research proposal we must consider that the efforts on the subjects enumerated here are world wide and have been for many years. It would be difficult to see a competitive research effort at the site. If on the other hand it is an engineering proposal, it is a list of what we don't know which is also the entire field of hydrology. What we can do from an engineering standpoint must be evaluated to see if it furnishes the required conclusions realistically. The report tries to list every subject in hydrology. The report could be immensely reduced in size if we listed what we know and what we can do in the required short period of time. Accordingly the list of the indeterminate problems listed would be equally long.

REVIEWER: H.E. Skibitzke

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 43 CHAPTER NO.: 8

SEC. NO.: 3.1.2.1.2.1 PAGE. NO.: 103 FIG./TABL:

COMMENT

Surface water runoff monitoring will require a period of sampling that will extend beyond any real decision making period. Data from such a program would be essentially useless without a 10-50 year sampling period. Since heavy rainfall is so sporadic in the area the 50 year period would more nearly be true. Criterions for statistical analysis have not been set for this project. In spite of this being of far reaching importance in environmental evaluation, the need for data as expressed here would be unsatisfactory even in a bridge design program.

REVIEWER: H.E. Skibitzke

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 44 CHAPTER NO.: 8

SEC. NO.: 3.1.2.2-2a PAGE. NO.: 52 FIG./TABL: 8.3.1.2-2a

COMMENT

Stratigraphy

The column titled "Needed Confidence in Parameter or Performance Measure" will have to be quantitative. "Statistical Homogeneity" (Internal Geometry-stratigraphy) will not suffice since the heterogeneities go through several magnitudes (eg, 6) of parameter variation yet the needed confidence is obviously high as defined here.

REVIEWER: H.E. Skibitzke

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 45 CHAPTER NO.: 8

SEC. NO.: 3.1.2.2-2a PAGE. NO.: 52 FIG./TABL: 8.3.1.2-2a

COMMENT

Pages 52, 53, 54

Internal Geometry

The description of the internal geometry in all cases are defined by a discontinuous, heterogeneous sets of data. This leads one to look for measurement techniques and evaluation measurements in the following report, they do not seem to be forthcoming.

On page 54 the top ROW describes the need for data on anisotropy. It apparently is not contained in the succeeding portions of the report. With the variation of parameter magnitudes defined here equivalent porous medium would not be a useful concept. To regard them as distinct hydrologic entities is to disregard the principle control on the flow system, the widely varying fracture system.

REVIEWER: H.E. Skibitzke

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE-RW-199 AUTHOR: NONE

COMMENT NO.: 46 CHAPTER NO.: 8

SEC. NO.: 3.1.2.2-2a PAGE. NO.: 56 FIG./TABL: 3.1.2.2-2a

COMMENT

Driving Forces

Equation of Motion- 1st line
Permeability is a tensor (Dyadic Product) or is path controlled.
The driving force and flow vector are not parallel.

Conservation of Mass-

Much of the liquid in this system is essentially not moving. An important consideration in moisture logging by such devices as neutron logging. The liquid is contained in fracture systems that retard movement so severely as to not be part of any present phase of motion. Further from a volume standpoint the amount of liquid is very small. The liquid in storage being small does not change the probability of very high pressures at depth. Opening space at depth allows these high pressures to become high heads in the vicinity of the opening. Hence small volumes of water can exert extreme heads where the aquifer is disturbed.

REVIEWER: H.E. Skibitzke

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 47 CHAPTER NO.: 8

SEC. NO.: 3.1.2.2.9.3. PAGE. NO.: 356 FIG./TABL:

COMMENT

Required detail at the site could not be developed by boundary condition modeling. The emphasis in this type of modeling is on the control of the flow pattern by factors at a distance. The only value of such modeling would be furnishing a predictive vector at the site of the regional flow when modification of the regional flow occured. The vector, even in this case, would not represent the local changes due to heterogeneity. We must keep sight of the fact that the local phenomenon are of prime concern not some gross average. The emphasis should be local. For accomplishing this boundary conditions must be for real and not due to synthesizing computer aids since they then become the control. There are no boundary conditions other than a flow description at a local boundary. It then would be necessary to make time a variable with very little data to determine such variations. It would be infinitely better to determine today's configuration by a non-subjective technique and then add the future changes by superposition.

Review: Federal Register Vol. 53, No. 247, pages 1983-1984 which essentially contradicts the approach shown here.

REVIEWER: H.E. Skibitzke

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 48 CHAPTER NO.: 8

SEC. NO.: 3.1.2.2.9.4 PAGE. NO.: 359 FIG./TABL:

COMMENT

Page 273, Item 6

This site analysis requires geostatistical evaluation. At the center of such analyses are kriging techniques. There is no consideration of such analyses. It is difficult to see how Monte Carlo simulations could be applied to evaluate such factors as:
1. Geometric Distribution of Permeability
2. Hydraulic Head Distribution
3. Anisotropy of Fractures
4. Required detail of Flow Patterns at the site
This is the domain of kriging techniques. Further, geometric distribution of the standard deviation of such parameters would be required to ascertain the planning of test wells. As it appears in the pages following page 359 the approaches used would lead to variances so great that in spite of high costs and effort the data would be so poor that safe decisions could not be made. I suggest the very elementary GEOEAS program of the EPA be reviewed. This program should be brought to a high technical level using the mathematics described in such publications as Geostatistical Ore Reserve Estimation by M. David, Elsevier Geostatistics-McGraw Hill, 1980, as well as a recent rash of publications on this subject.

REVIEWER: H.E. Skibitzke

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 49 CHAPTER NO.: 8

SEC. NO.: 3.1.2.2.9.4. PAGE. NO.: 359 FIG./TABL:

COMMENT

The statistical variations at this site are of a spatial nature. This requires an approach given by polygonal; inverse weighting; least squares or kriging. Since kriging is the most sophisticated approach and is readily available it would be senseless not to have it make up the center of the analysis program. See as an example Chapter 4 of Geostatistics, McGraw Hill, 1980. Throughout this report we can find no criterions or techniques that are useable to give the standard deviations on a geographic position, near or within the site. Today when Kriging is becoming one of the major thrusts in contaminant evaluation it is surprising that this major problem in data reliability is ignoring what will become, in the final analysis, a most important consideration.

REVIEWER: H.E. Skibitzke

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 50 CHAPTER NO.: 8

SEC. NO.: 3.1.2.8-2a PAGE. NO.: 54 FIG./TABL: 8.3.1.2-2a

COMMENT

Lateral Geometry

Eastward dipping Fault Blocks

The vertical downward gravitational force is applied through a tensor permeability or a path controlled permeability (Fracture Patterns). The permeability is therefore directional giving a flow pattern vertically downward. How much of these data will be available is hard to discern but it must be known or the remainder of the effort will be misleading.

REVIEWER: H.E. Skibitzke

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 51 CHAPTER NO.: 8

SEC. NO.: 3.1.4. PAGE. NO.: 17-18 FIG./TABL:

COMMENT

It is not apparent how the studies given in the final column of Table 8.3.1.4-2 will reduce uncertainty. The criteria for acceptance, the method of analysis, both appear to be TBD at this point for much of the program.

REVIEWER: D.H. Dahlem

D.H. Dahlem

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE-W-199 AUTHOR: NONE

COMMENT NO.: 52 CHAPTER NO.: 8

SEC. NO.: 3.1.16-31. PAGE. NO.: 31 FIG./TABL: 8.3.1.16-3

COMMENT

Wells for construction water should not be on site because of the pathways problem. No discussion treats this issue.

REVIEWER: D.H. Dahlem

D.H. Dahlem

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 53 CHAPTER NO.: 3

SEC. NO.: 3.2.1 PAGE. NO.: 3 FIG./TABL:

COMMENT

An acceptable representation of the hydrologic considerations cannot be determined at this time. Data collection on flooding and stream flow in ephemeral stream channels throughout Nevada began in the early 1960's and stopped in 1980. Historical data was not collected in the region where the respository is proposed, until recently. The SCP notes that long-range flood predictions are difficult to make even for drainages that have stream flow records as long as 100 years, especially for extreme areal variability of flood flows in arid climates. The Squires and Young (1984) study is considered the best available method for determining the peak discharges and it is based on data from a short record period (15 to 20 years) which was from a "nearby" area. There has been no collection of historical data for infiltration through the unsaturated zones or recharge into the saturated zones.

REVIEWER: Colleen R. Stout

Colleen Raye Stout
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-15-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 54 CHAPTER NO.: 8

SEC. NO.: 3.5. PAGE. NO.: 14 FIG./TABL: 8.2.5.12-5

COMMENT

Section does not show transport across OT/CH nv or n2/TSW contacts, however faulting suggests there should be some exchange. This is conceptually important in pathway analysis.

REVIEWER: D.H. Dahlem

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 55 CHAPTER NO.: 8

SEC. NO.: 3.5.12. PAGE. NO.: 5 FIG./TABL:

COMMENT

The statement in paragraph 3 suggests fracture flow should be discounted, however it is the only mechanism by which transport times will be sufficiently short to show the site unsuited. Therefore it deserves the utmost care and attention.

REVIEWER: D.H. Dahlem

D.H. Dahlem

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 56 CHAPTER NO.: 8

SEC. NO.: 3.5.12 PAGE. NO.: 6 FIG./TABL:

COMMENT

The strategy seems flawed because one system of network fractures could provide "all fracture" transport to the accessible environment.

REVIEWER: D.H. Dahlem

D.H. Dahlem

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

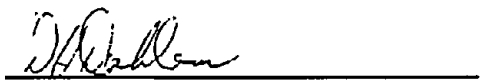
COMMENT NO.: 57 CHAPTER NO.: 8

SEC. NO.: 3.5.12-44 PAGE. NO.: 44 FIG./TABL:

COMMENT

The modeling approach is logical and accounts for the major processes however the inability to validate the calculations steming from the lack of real data at the repository will make the estimates of travel time somewhat suspect.

REVIEWER: D.H. Dahlem



Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 58 CHAPTER NO.: 8

SEC. NO.: 3.5.12 PAGE. NO.: 48 FIG./TABL:

COMMENT

Validation of the full system is not possible and any discussion of validation should be careful to point out which parts of the system are being validated and which parts are not. Then the discussion should treat the possible consequences from the subsystems not validated.

REVIEWER: D.H. Dahlem

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 59 CHAPTER NO.: 8

SEC. NO.: 3.5.12. PAGE. NO.: 50 FIG./TABL:

COMMENT

All of this discussion relates to travel time, but mixed in is the concept of radionuclide transport. These should be kept separate. Radionuclide transport is probably somewhat slower and may be significantly slower than liquid water transport, given the sorbing and partitioning mechanisms extent in the tuff/glass rock assemblage.

REVIEWER: D.H. Dahlem

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 60 CHAPTER NO.: 8

SEC. NO.: 3.5.15 PAGE. NO.: 6 & 7 FIG./TABL:

COMMENT

The logic of protection assumes enough is known about the aquifers to say no inter-unit contamination will exist and essentially that no co-mingling between the surficial, tuff, and carbonate aquifer will happen. I believe insufficient data exists to make that point.

Technically DOE may not have to address the issue because a special source may not exist, but the State's position should be that if co-mingling cannot be dismissed, in the event dispersion may happen, the issue is not closed.

REVIEWER: D.H. Dahlem

D.H. Dahlem

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 61 CHAPTER NO.: 3

SEC. NO.: 3.6.1 PAGE. NO.: 50 FIG./TABL:

COMMENT

The discussion of the hydrogeologic units presented in Section 6 reflects a complex ground-water system with limited available data. It appears that it will be difficult to obtain within a relatively short time frame the information needed to define conditions with much preciseness, even on a general site-specific basis.

REVIEWER: MERVIN L. KLUG

Mervin L. Klug
Signature

ORGANIZATION: GUYTON ASSOCIATES

DATE: 5-31-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 62 CHAPTER NO.: 3

SEC. NO.: 3.7.2 PAGE. NO.: 74 FIG./TABL:

COMMENT

Section 3.7.2 discusses principal ground-water flow paths and points to the lower carbonate aquifer as being the principal conduit to points of natural discharge. However, in much of the discussion reference is made to downward flow of water through volcanic-rock aquifers to reach the lower carbonate aquifer. If this is so, there must be some mechanism by which the water is able to get through the volcanic-rock aquitards. Elsewhere in the SCP these aquitards are inferred to be very restrictive to movement of water through them. Thus, it appears passage of water through aquitards needs additional study.

REVIEWER: MERVIN L. KLUG

Mervin L. Klug
Signature

ORGANIZATION: GUYTON ASSOCIATES

DATE: 5-31-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 63 CHAPTER NO.: 3

SEC. NO.: 3.7.3.1.2 PAGE. NO.: 87 FIG./TABL:

COMMENT

The section on recharge and discharge mechanisms (3.7.3.1.2) makes frequent reference to place names in the region. There is no single map which shows these sites, and as a result it is not easy to follow the text and understand the mechanisms being described. Because of this, there are parts of this discussion which I do not understand sufficiently to comment on.

REVIEWER: MERVIN L. KLUG

Mervin L. Klug
Signature

ORGANIZATION: GUYTON ASSOCIATES

DATE: 5-31-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 64 CHAPTER NO.: 3

SEC. NO.: 3.9 PAGE. NO.: 136 FIG./TABL:

COMMENT

Section 3.9 discusses the site hydrologic system and points out two things; its complexity and how little is known about it. The scientific community has only recently given much attention to the unsaturated zone, and very little of this attention has been concerned with volcanic rocks such as those at Yucca Mountain. Developing data useful in describing and evaluating these conditions at Yucca Mountain is for the most part exploring new territory. Doing this in connection with proving up a site for construction of a repository for high-level nuclear waste requires that it be done right. Therefore, new approaches should be completely understood and evaluated before using them to develop information at Yucca Mountain.

REVIEWER: MERVIN L. KLUG

Mervin L. Klug
Signature

ORGANIZATION: GUYTON ASSOCIATES

DATE: 5-31-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 65 CHAPTER NO.: 3

SEC. NO.: 3.9 PAGE. NO.: 137 FIG./TABL:

COMMENT

The second paragraph on page 137 refers to potentiometric heads for rocks below the Topopah Springs and other upper hydrogeological units being greater than they are in the water-table aquifer. If water can leak downward from the water-table aquifer through volcanic-rock materials and enter the lower cabonate aquifer elsewhere in the region, there should be no reason why in this instance water cannot move upward into the water-table aquifer. The driving head for accomplishing this appears admittedly small, but some movement should be expected. If as indicated these conditions do exist, they need to be addressed in discussing flow paths and the mixing of waters.

REVIEWER: MERVIN L. KLUG

Mervin L. Klug
Signature

ORGANIZATION: GUYTON ASSOCIATES

DATE: 5-31-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 66 CHAPTER NO.: 3

SEC. NO.: 3.9.3 PAGE. NO.: 196 FIG./TABL:

COMMENT

Under Item 8 on this page, the subject is temperature-driven moisture transport in the unsaturated Topopah Springs. If there is upward movement of water vapor, it appears this movement might transport radionuclides to the surface environment. This needs to be addressed as part of the SCP if this is not already done in another section. While this may not be a problem under pre-repository conditions, the heat generated from storage of the waste could have a major effect on vapor movement and transport.

REVIEWER: MERVIN L. KLUG

Mervin L. Klug
Signature

ORGANIZATION: GUYTON ASSOCIATES

DATE: 5-31-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 67 CHAPTER NO.: 3

SEC. NO.: 3.9.3 PAGE. NO.: 197 FIG./TABL:

COMMENT

The fourth paragraph on this page discusses interaction of water in the shallow part of the saturated zone in the vicinity of the repository block with water in the deeper Paleozoic rocks. It says that ground water moving through the shallow part of the saturated zone probably does not have significant local interaction with water from Paleozoic rocks because water in the Paleozoic rocks has a higher potentiometric head. It appears that if the Paleozoic rocks have the higher potentiometric head, water from them should be entering and mixing with water in the shallow part of the saturated zone. This is not addressed.

REVIEWER: MERVIN L. KLUG

Mervin L. Klug
Signature

ORGANIZATION: GUYTON ASSOCIATES

DATE: 5-31-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 68 CHAPTER NO.: 3

SEC. NO.: 3.9.4 PAGE. NO.: 215 FIG./TABL: 3-46

COMMENT

Figure 3-46 presents a conceptual hydrogeologic section from Solitario Canyon northwest of the site to Well J-13 in Jackass Flats. It is similar to other conceptual hydrogeologic sections presented in the SCP, and shows flow paths for water moving eastward from the Solitario Canyon end of the section. Elsewhere in the SCP statements are made that the Solitario Canyon fault shown at the left of the section forms a barrier to ground-water flow. Its displacement is shown to be from 20 to 200 meters. The question then is where does the water to support the flow path shown at the left of the section come from. Water-level contours presented in other figures of the SCP indicate there is flow across the fault. This inconsistency needs to be resolved.

REVIEWER: MERVIN L. KLUG

Mervin L. Klug
Signature

ORGANIZATION: GUYTON ASSOCIATES

DATE: 5-31-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 69 CHAPTER NO.: 3

SEC. NO.: 3.10.2 PAGE. NO.: 238 FIG./TABL:

COMMENT

The third paragraph on page 238 states that potential interaction between container walls and moisture in the emplacement holes is a consideration in estimating the lifetime of the canisters. It appears evident from the discussion presented in chapter 3 that moisture will be present in the host rock, whether in the rock matrix or through fractures. Therefore a matter of major concern is determining the amount and quality of the water and the engineering design required to protect against its presence.

REVIEWER: MERVIN L. KLUG

Mervin L. Klug
Signature

ORGANIZATION: GUYTON ASSOCIATES

DATE: 5-31-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: Reactivity of Tuff-Bearing Concrete
DOCUMENT NO.: LA-11532-MS AUTHOR: Los Alamos

COMMENT NO.: 70 CHAPTER NO.: 4

SEC. NO.: 4 PAGE. NO.: 63 FIG./TABL:

COMMENT

The results of just a few months of testing reveal the possibility of unpredictable mechanical properties due to the vitreous component of the tuff and the chemical activity of the glassy components. This will greatly affect the long-term performance of the repository seals.

REVIEWER: H. P. Thompson

H. P. Thompson
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-19-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: Reactivity of Tuff-Bearing Concrete
DOCUMENT NO.: LA-11532-MS AUTHOR: Los Alamos

COMMENT NO.: 71 CHAPTER NO.: 4

SEC. NO.: 4 PAGE. NO.: 63 FIG./TABL:

COMMENT

Since the host horizon is in the unsaturated tuff and the long-term forecast of elevated temperatures, it is very possible that the seals may be altered, which suggests the possibility or probability of contamination and leaks from the respository area to the saturated tuff.

REVIEWER: H. P. Thompson

H. P. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06-19-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: Reactivity of Tuff-Bearing Concrete
DOCUMENT NO.: LA-11532-MS AUTHOR: Los Alamos

COMMENT NO.: 72 CHAPTER NO.: 4

SEC. NO.: 4 PAGE. NO.: 63 FIG./TABL:

COMMENT

Although expansive cements are proposed or are being studied for use in the repository, subsequent to the hydrothermal experiments, the product "ettringite" was no longer found to be present in the samples. This "ettringite" is the prime product responsible for the expansive properties of the cement, and the concern over the loss of this product is that the concrete seal will shrink and crack in the same manner that normal portland cements perform. Without proper treatment of this property of concrete, the seals will be compromised to the extent that they may become virtually useless.

REVIEWER: H. P. Thompson

H. P. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 6-20-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: Reactivity of a Tuff-Bearing Concrete
DOCUMENT NO.: LS-11532-MS AUTHOR: Los Alamos

COMMENT NO.: 73 CHAPTER NO.: 4

SEC. NO.: 4 PAGE. NO.: 64 FIG./TABL:

COMMENT

Another concern about the loss of the matrix phase "ettringite" is the release of sulfate to the groundwater causing an imbalance in the chemical activity which would encourage the increase in the permeability of the seal. Actually, the permeability may be compromised to a greater degree than nonexpansive cements due to the formation of interconnected needle-like crystals creating conduits for fluid transfer. This is the last thing we want to happen to seals and should precipitate the investigation for alternate seal mediums.

REVIEWER: H. P. Thompson

H. P. Thompson
Signature

ORGANIZATION: Thompson Eng.

DATE: 6-20-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: Studies of Ancient Concrete
DOCUMENT NO.: LA-11527-MS AUTHOR: Los Alamos

COMMENT NO.: 74 CHAPTER NO.: 4

SEC. NO.: 4.2 PAGE. NO.: 57 FIG./TABL:

COMMENT

The surface conditions of the Yucca Mountain site may resemble the conditions of the investigation of the cementitious materials, but the near-surface conditions of the repository will vary considerably from the surface environment. Further, most all of the applications of the materials studied were used as a mortar to secure the basic building stones, which were the primary structural components of the feature.

REVIEWER: H. P. Thompson

H. P. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06-19-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Overview
DOCUMENT NO.: DOE/RW-0198 AUTHOR: DOE

COMMENT NO.: 75 CHAPTER NO.: 4

SEC. NO.: 4.2.1.1 PAGE. NO.: 62 FIG./TABL:

COMMENT

I am concerned about the results of "flash floods" and the associated velocity of the runoff. Structures constructed in the path of these floods can be substantially damaged by not only the runoff, but more importantly, from large boulder impacts. Concentrating the runoff in diversion ditches only increases the velocity and danger as well as the possibility of undercutting the structure due to erosion.

REVIEWER: H. P. Thompson

H. P. Thompson
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-14-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Overview
DOCUMENT NO.: DOE/RW-0198 AUTHOR: DOE

COMMENT NO.: 76 CHAPTER NO.: 4

SEC. NO.: 4.2.1.1 PAGE. NO.: 64 FIG./TABL:

COMMENT

Standby electrical power is mandatory for the safety of the workers; however, I am concerned about the protection of the generators from flash floods and rock impacts. The most probable time interval for the standby power will be during a violent storm which produce extensive runoff. The standby power equipment and service lines must be isolated from any possibility of damage.

REVIEWER: H. P. Thompson

H. P. Thompson
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-14-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Overview
DOCUMENT NO.: DOE/RW-1098 AUTHOR: DOE

COMMENT NO.: 77 CHAPTER NO.: 4

SEC. NO.: 4.2.1.1 PAGE. NO.: 65 FIG./TABL:

COMMENT

The mining wastewater is proposed to be deposited into a settling and evaporation pond. It is unclear as to what provisions are being made for treatment of this wastewater due to contamination after the repository begins accepting HLNW for depositing in the horizon tuff. The continued construction of drifts will occur in the same time frame as the depositing of HLNW.

REVIEWER: H. P. Thompson

H. P. Thompson
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-14-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Overview
DOCUMENT NO.: DOE/RW-0198 AUTHOR: DOE

COMMENT NO.: 78 CHAPTER NO.: 4

SEC. NO.: 4.2.1.1 PAGE. NO.: 65 FIG./TABL:

COMMENT

The shaft collar is constructed of reinforced concrete and provides a foundation for "supporting" the concrete liner of the shaft. If this is true and neglecting the sidewall friction, this collar must "hang" over 6,750 kips or 3,375 tons of concrete liner requiring a minimum of 112.5 square inches of G-60 steel calculated at the yield strength of a G-60 bar.

REVIEWER: H. P. Thompson

H. P. Thompson
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-15-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Overview
DOCUMENT NO.: DOE/RW-0198 AUTHOR: DOE

COMMENT NO.: 79 CHAPTER NO.: 4

SEC. NO.: 4.2.1.2 PAGE. NO.: 67 FIG./TABL:

COMMENT

Placing the shaft concrete liner in 20-foot segiments of unreinforced concrete does not meet ACI specifications. Further, there is no connection between segments for supporting the liner from the shaft collar. Shrinkage of the concrete in one 20-foot section may be as much or more than 3/16", and in the full length of the shaft as much or more than 10 1/2" depending upon the composition and design of the mix.

REVIEWER: H. P. Thompson

H. P. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06-15-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 80 CHAPTER NO.: 4

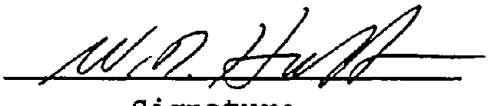
SEC. NO.: 4.4.7-3 PAGE. NO.: 335 FIG./TABL:

COMMENT

The section titled Hydrologic Analysis (4.4.7-3) addresses regional floods as presented in a 1984 study performedby Squires and Young. The fifth (5th) paragraph of Section 4.4.7-3 states "the results of the study were considered in the siting of the surface facilities and in the conceptual design of the flood protection features," however, it goes on to say "no explicit design calculations were performed to support the conceptual design of flood protection features."

While it is not uncommon to use this approach on normal schedule projects, it appears this could be disastrous on a fast track project like the Yucca Mountain site where many studies and preliminary design work are proceeding based on anticipated locations and features, if later calculations raise questions on the results of the Squires and Young report.

REVIEWER: W. D. Huff



Signature

ORGANIZATION: Thompson Eng.

DATE: 05-23-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Overview
DOCUMENT NO.: DOE/RW-0198 AUTHOR: DOE

COMMENT NO.: 81 CHAPTER NO.: 5

SEC. NO.: 5.1.1 PAGE. NO.: 84&85 FIG./TABL:

COMMENT

In evaluating the repository system, all combinations of the three major events must be considered simultaneously and not just on an individual basis.

REVIEWER: H. P. Thompson

H. P. Thompson
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 82 CHAPTER NO.: 6

SEC. NO.: 6.1 PAGE. NO.: 71 FIG./TABL:

COMMENT

Published literature also shows that structures can be designed to resist moderate surface displacement before any catastrophic failure could occur. There is no statement as to whether any of the planned structures are being considered for such a design.

REVIEWER: Philip Murphy

Signature

ORGANIZATION: Dunn

DATE: 06-05-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 83 CHAPTER NO.: 6

SEC. NO.: 6.1 PAGE. NO.: 86 FIG./TABL:

COMMENT

Figure 6-12 is the overall site plan which shows the surface facilities and shafts. There is enough detail in the figure to illustrate the proposed locations of the electrical conduits, water lines, and a pipeline. There are also berms shown in the figure which presumably are for the purpose of diverting surface runoff away from the facility. If this is true, the berms in the area of the tuff pile need reexamination and the stream courses redrawn to their new location.

REVIEWER: Philip Murphy

Signature

ORGANIZATION: Dunn

DATE: 06-05-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 84 CHAPTER NO.: 6

SEC. NO.: 6.1.1.2 PAGE. NO.: 8 FIG./TABL:

COMMENT

The DOE has established directives regarding the functional requirements of a repository. These directives consist of: 1) guidance and policy issued by the Office of Geologic Repositories for the Geologic Disposal of Radioactive Waste, and 2) requirements in the form of DOE orders that apply generally to all DOE projects and are written to establish policy and procedures for DOE activities. The directives are summarized in Table 6-4. The DOE and functional requirements developed from the directives are summarized in Table 6-5. The performance confirmation and closure phase functions and specific requirements are summarized in Table 6-6.

While the directives and functional requirements appear to be complete and comprehensive, I do not find a specific written procedure mechanism for their text to be changed, modified, expanded, or deleted based on findings of the site characterization. Changes most certainly will be required since this is the first repository designed for high level nuclear waste.

REVIEWER: W. D. Huff

W. D. Huff
Signature

ORGANIZATION: Thompson Eng.

DATE: 05-18-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 85 CHAPTER NO.: 6

SEC. NO.: 6.1.2.4 PAGE. NO.: 62 FIG./TABL:

COMMENT

Thermal properties may be affected by the degree of fracturing, the inhomogeneities in structure and minerology. These variations may be small, however their effect on design should be investigated. The statement that good agreement exists between lab and in situ valves should be qualified as an approximation. (p6-62, #2)

REVIEWER: D.H. Dahlem

D.H. Dahlem

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 86 CHAPTER NO.: 6

SEC. NO.: 6.1.2.6 PAGE. NO.: 6 FIG./TABL:

COMMENT

It is noted herein that the flood plain limits established for the Yucca Mountain site are based on information from surrounding areas and not on site-specific characteristics. Since surface water drainage is a major consideration in establishing the site's suitability and several of the proposed facilities lie within or near the preliminary flood plain limits, it would be advisable to establish the probable maximum flood in accordance with ANSI/ANS 2.8(1981) at this time instead of waiting til later stages of design. This detailed study should include analysis of the flow through the existing draw in which the ESF facilities are proposed.

REVIEWER: Colleen R. Stout

Colleen Raye Stout
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-15-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 87 CHAPTER NO.: 6

SEC. NO.: 6.2 PAGE. NO.: 124 FIG./TABL:

COMMENT

A number of advantages for the chosing of this particular plan were mentioned. One reason was the protection from flash flooding. In comparing Figures 6-8 (pages 6-69) and Figures 6-48 (pages 6-125), the railroad yards and truck park are located in a flood prone area. Presumably the rail cars and trucks would still have waste containers onboard while in the yard and truck park.

REVIEWER: Philip Murphy

Philip Murphy
Signature

ORGANIZATION: Dunn

DATE: 06-05-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 88 CHAPTER NO.: 6

SEC. NO.: 6.2 PAGE. NO.: 127 FIG./TABL:

COMMENT

The figure shows the locations of the six candidate areas for the surface facilities. The numbers go up to 8. Numbers 1 and 6 are missing.

REVIEWER: Philip Murphy

Signature

ORGANIZATION: Dunn

DATE: 06-05-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 89 CHAPTER NO.: 6

SEC. NO.: 6.2 PAGE. NO.: 129 FIG./TABL:

COMMENT

Figure 6-51 shows the surface facilities of shaft sites. The water diversion cut on the south side needs a water course symbol drawn to show where the water will go. The same is true for the north diversion cut but some consideration must be given to divert the exiting water under the road leading to the explosive magazines rather than across it as presently drawn.

REVIEWER: Philip Murphy

Signature

ORGANIZATION: Dunn

DATE: 6-08-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 90 CHAPTER NO.: 6

SEC. NO.: 6.2 PAGE. NO.: 134 FIG./TABL:

COMMENT

Flood protection structures should not only be designed for water but also for the erosive potential such floodwaters may have.

REVIEWER: Philip Murphy

Philip Murphy
Signature

ORGANIZATION: Dunn

DATE: 6-08-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 91 CHAPTER NO.: 6

SEC. NO.: 6.2 PAGE. NO.: 152 FIG./TABL:

COMMENT

Figure 6-65 shows the panel details for horizontal emplacement. At the top of the drawing the horizontal boreholes are specified to be drilled in 37 foot diameters, on 36 foot centers. The maximum height ofthe panel access drift is 14 feet. Some arithemetic adjustments are needed.

REVIEWER: Philip Murphy

Signature

ORGANIZATION: Dunn

DATE: 6-08-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 92 CHAPTER NO.: 6

SEC. NO.: 6.2.3.1.1 PAGE. NO.: 89 FIG./TABL:

COMMENT

A question arises as to the expected site-generated radioactive waste volumes and whether a study is required to address the proposed off-site disposal contingency.

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 93 CHAPTER NO.: 6

SEC. NO.: 6.2.3.1.1 PAGE. NO.: 6 FIG./TABL: 6-15

COMMENT

In the waste-handling of the spent fuel, this section of the SCP notes that for both Phase I and Phase II, the spent fuel would be unloaded from the shipping cask and loaded into disposal containers where they would be filled with an inert gas sealed by welding and inspected for leaks. It does not specify how the original shipping casks are to be handled or disposed of once the hazardous material is unloaded, especially if they are contaminated. It just states they are to be returned to the carrier which will leave the respository.

REVIEWER: Colleen R. Stout

Colleen Ray Stout
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-14-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 94 CHAPTER NO.: 6

SEC. NO.: 6.2.3.1.2.2 PAGE. NO.: 6 FIG./TABL:

COMMENT

The figure showing emplacement of a waste package in a horizontal borehole shows a single canister being placed and not how multiple canisters are to be placed. Fourteen to eighteen containers are proposed to be placed in each horizontal borehole. It is not clear as to whether all the containers are to be placed at once and the shield plug is to be installed; or if they all place individually and the borehole remains open til it is full. It is also not clear as to whether the extension plate on the transporter is intended to push the container all the way back into the borehole (297 feet to 363 feet) or if the following containers placed push the previous ones back. If so, the container caps need to be designed for this force.

REVIEWER: Colleen R. Stout

Colleen Raye Stout
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 95 CHAPTER NO.: 6

SEC. NO.: 6.2.3.1.3 PAGE. NO.: 6 FIG./TABL:

COMMENT

Mechanical equipment is proposed to unload, transfer, and seal the hazardous material as it arrives at the repository and prior to storage. It is not discussed how mechanical failures or repairs are to be handled.

REVIEWER: Colleen R. Stout

Colleen Raye Stout
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-15-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 96 CHAPTER NO.: 6

SEC. NO.: 6.2.3.1.3 PAGE. NO.: 110 FIG./TABL:

COMMENT

An assessment of the impact of the equipment required that will provide the technical capability for accurately drilling and lining horizontal boreholes is needed at this stage. Since the design layout of the proposed repository is critically contingent on the availability of the technological capabilities to develop such equipment, it is deemed important that the capability to develop the equipment in question be demonstrated before any further thought to the waste-package emplacement methods.

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi

Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 97 CHAPTER NO.: 6

SEC. NO.: 6.2.4.1 PAGE. NO.: 134 FIG./TABL:

COMMENT

Unless a more site-specific elaboration can be made on the soil characteristics concerning surface-facilities foundation design, the validity of the statement that measurements "can be considered conservative estimates for properties of the deeper foundation soils, because soil strength normally increases with confining pressure .... and depth," becomes questionable. Soil strength is not a function of depth but of soil properties.

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi

Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 98 CHAPTER NO.: 6

SEC. NO.: 6.2.6 PAGE. NO.: 148 FIG./TABL:

COMMENT

The description of the general layout of the vertical emplacement associated with standoff distances does not instill confidence in the performance objectives of the repository. The stated current design minimum standoff of 85 ft. was based on theoretically derived solution that may prove to be inaccurate once the site characterization activities are completed. An assessment of the impact of possible modification that might require an increase in this standoff distance on the overall repository performance and storage capacity is needed.

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 99 CHAPTER NO.: 6

SEC. NO.: 6.2.6 PAGE. NO.: 148 FIG./TABL:

COMMENT

In the process of describing the general layout of the horizontal emplacement, it stated that the panel would be 427 meters high. This is obviously a typographical error that should be corrected.

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi

Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 100 CHAPTER NO.: 6

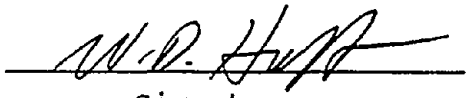
SEC. NO.: 6.2.6.2 PAGE. NO.: 164 FIG./TABL:

COMMENT

It is stated in Section 6.2.6.2 that all underground areas would drain in the direction of a sump located in the bottom of the emplacement area exhaust shaft, the lowest point in the underground facility. From this location, the water would be pumped to the surface through the emplacement area exhaust shaft. Backup pumps would be available to ensure adequate pumping capacity.

Water being the critical concern of contamination transport, I feel this section falls short of adequately addressing the subject of groundwater control in the repository should it be encountered. What is the contingency plan for pumping should a serious event in the exhaust shaft render the primary and backup pumps inoperable, are there other pumps, could they sustain the potentially serious event that incapacitated the exhaust shaft pumps? Why not consider chamber doors in the drifts as a backup isolation method?

REVIEWER: W. D. Huff



Signature

ORGANIZATION: Thompson Eng.

DATE: 05-18-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 101 CHAPTER NO.: 6

SEC. NO.: 6.2.7.1 PAGE. NO.: 177 FIG./TABL:

COMMENT

At the current design stage with its inherent short comings based on lack of concrete data base, a statement concerning the backfilling of mined opening following emplacement can not be made with any confidence, as was the case here. The complexity of the repository's design with the different interrelated subsystems being simultaneously in the evaluation stage requires that each subsystem be evaluated based on its own technical and engineering merits. For example, the need for backfill as a means of structural support for mined openings before closure was discounted stating in the process that stability, if need be, will be provided by ground support system. But at the same time, the ground support system is at an evaluation stage of its own and might prove to have adverse effect on the repository's isolation performance objectives that deem it unusable.

It is not considered prudent to discount the possibility of backfilling based on the hope that the evaluation of ground support system's performance will prove to be acceptable.

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 102 CHAPTER NO.: 6

SEC. NO.: 6.2.7.2 PAGE. NO.: 177 FIG./TABL:

COMMENT

Current planning for backfill at closure includes the use of water to control dust, improve compaction, or both. It is stated that limited quantities will be used with excess water being removed "the same as water introduced during development activities."

This is an inconsistent statement in that voids are being filled and closed, not created and opened, as during excavation when water can freely flow and be pumped. In fact, if optimum moisture content is maintained, why should there be excess water? Other mediums should be investigated, water is not the only dust suppresant or binder medium.

REVIEWER: W. D. Huff

Signature

ORGANIZATION: Thompson Eng.

DATE: 05-18-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 103 CHAPTER NO.: 6

SEC. NO.: 6.2.7.2 PAGE. NO.: 177 FIG./TABL:

COMMENT

Clarity as to the basis of assuming that the flux in the rock media is less than that of the hydraulic conductivity of the matrix is needed to verify the validity of the authors' reasoning to assume that the fractures "do not transmit water."

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 104 CHAPTER NO.: 6

SEC. NO.: 6.2.8 PAGE. NO.: 178 FIG./TABL:

COMMENT

One of the funtions of the sealing system is to prevent or reduce the potential for creating a preferential pathway for ground water. Considering the fracturing (described in Chapter 1) and the potential for fracturing during excavation a preliminary design has been chosen for tunnel support. This very design will prevent any sealing system from extending beyond the tunnel support into the fractures around the tunnels or shafts. Figures 6-78 (page 6-180) and 6-79 (page 6-182) illustrate the seals extending beyound the walls of the tunnels and shafts but there is no mention made of making this a standard procedure in the text. Section 6.2.9 partly addresses this issue but only in islolating water bearing fractures and fault zones.

REVIEWER: Philip Murphy

Philip Murphy
Signature

ORGANIZATION: Dunn

DATE: 6-08-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 105 CHAPTER NO.: 6

SEC. NO.: 6.2.8.2 PAGE. NO.: 6 FIG./TABL:

COMMENT

The shafts are proposed to be backfilled with a coarse, well-graded material to reduce settlement and to permit drainage of water. The proposed collars at the top of the shafts warrant careful considerations during construction to minimize impact to the surrounding rock wall's permeability. There is a potential for significant amounts of surface water to enter and fill the shafts over time if surface cracks or permeability is increased.

REVIEWER: Colleen R. Stout

Colleen Rae Stout
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 106 CHAPTER NO.: 6

SEC. NO.: 6.4.2.2 PAGE. NO.: 221 FIG./TABL:

COMMENT

Section 6.4.2.2 titled Work Completed states "significant results have been reported to date for six products." Product 1.11.1-2 Reference Thermal/Mechanical Stratigraphy is one of the six listed. The first sentence of the second paragraph under the data section on pages 6-222 states "Specification of the accuracy of the model is difficult." The paragraph goes on to defend and soften this statement but concludes by saying "additional data collected during site characterization will be used to improve the confidence in the geometric model outside the primary area."

The purpose of the characterization program is to obtain data for site characterization, however, with such important information lacking in this area, I feel the initial accuracy statement on the model may be more accurate than the softened statement, which if true, will possibly effect the design schedule.

REVIEWER: W. D. Huff

Signature

ORGANIZATION: Thompson Eng.

DATE: 05-22-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 107 CHAPTER NO.: 6

SEC. NO.: 6.4.2.2 PAGE. NO.: 224 FIG./TABL:

COMMENT

Product 1.11.3-1 Area Needed Determination, one of the products for issue 1.11 appears to have the potential to impact the work done on other products in a very negative way. The three criteria used to calculate the area requirements do not list an identifiable contingency in the data section. Also, the results section list an uncertainty in the area needed of +-210 acres, based on uncertainty in the final basis APD of 40 to 80 kw/acre (appendix M of SNL, 1987). The current layout occupies 1420 acres. This is an approximate 15% (210/1420 = .148) unknown. I question what primary area the other product studies are being conducted on, especially the study on thermal/mechanical stratigraphy.

REVIEWER: W. D. Huff

W. D. Huff

Signature

ORGANIZATION: Thompson Eng.

DATE: 05-22-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 108 CHAPTER NO.: 6

SEC. NO.: 6.4.10 PAGE. NO.: 318 FIG./TABL:

COMMENT

The results of tunnel indexing or rock mass classification methods (CSIR and NGI) were applied to the waste emplacement horizon of Yucca Mountain. These results do not account for stresses caused by weapons testing or seismic events.

REVIEWER: Philip Murphy

Signature

ORGANIZATION: Dunn

DATE: 6-08-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 109 CHAPTER NO.: 7

SEC. NO.: 7.2.1.3.3 PAGE. NO.: 16 FIG./TABL:

COMMENT

In the process of describing the waste form's temperature limitation criteria, a reference is made to a transition temperature without any further treatment of the subject matter. The need to address issues of specificity, when dealing with reference material, is obvious in this case.

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-20-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 110 CHAPTER NO.:

SEC. NO.: PAGE. NO.: FIG./TABL:

COMMENT

The extent of the spent fuel storage testing program's duration in the process of determining the impact of the inert cover gas on the fuel and cladding degradation performance is required. For no matter how long the tests were, a certain degree of degradation will result with time that must be recognized, especially under such adverse performance conditions. Thus, it is critical that a new line of reasoning be taken to address the degradation potential of the fuel and the cladding.

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi

Signature

ORGANIZATION: Thompson Eng.

DATE: 06-20-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 111 CHAPTER NO.: 7

SEC. NO.: 7.2.3.1 PAGE. NO.: 18 FIG./TABL:

COMMENT

The possibility of producing a waste form geometry that is considered "critical arrangement" is hinted upon during the discussion of criticality control but was relegated to a facilities and equipment controlled product status. The implication of accidental production of critical form assembly cannot be dismissed this easily, with no further attention to the specifics of the problem.

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-20-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 112 CHAPTER NO.: 7

SEC. NO.: 7.3.1.1.1 PAGE. NO.: 24 FIG./TABL:

COMMENT

There is a need to address the procedural requirements to re-establish and incorporate the nonfuel hardware resulting from the preconsolidation operations and the structurally damaged "failed fuel" assemblies as they pertain to the reference fuel form. Also, an assessment study is required to address the failure to incorporate and provide for the aforementioned spent fuel forms (i.e., nonfuel and failed fuel) that may be received at the repository, during the conceptual design, for either the waste package or surface facilities and its impact on the overall repository storage objectives.

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi

Signature

ORGANIZATION: Thompson Eng.

DATE: 06-20-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 113 CHAPTER NO.: 8

SEC. NO.: 8.0 PAGE. NO.: 5 FIG./TABL:

COMMENT

It is stated throughout the SCP that the percolation of water through the unsaturated zone will primarily occur in the rock matrix. It is of the opinion of many hydrogeologists experienced with working in the unsaturated zone that the primary mechanism of flow will be through fractures.

REVIEWER: James F. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06/19/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 114 CHAPTER NO.: 8

SEC. NO.: 8.0 PAGE. NO.: 5 FIG./TABL:

COMMENT

Not until conclusive evidence supporting the suggested percolation patterns of water through the unsaturated rock matrix can the authors state that the water would be retained in the rock matrix and would not be expected to reach the waste. The scope of this project should not be based on suppositions and appearances.

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi

Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 115 CHAPTER NO.: 8

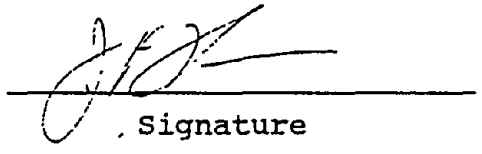
SEC. NO.: 8.0 PAGE. NO.: 5 FIG./TABL:

COMMENT

"To reach the emplaced waste, the water would have to penetrate the engineered-barrier system."

Considering the life of the repository and the historical life of engineered-barrier systems, it appears that too much emphasis is placed on the ability of an engineered-barrier to isolate waste migration. It is my opinion that the engineered-barrier could be rendered useless in less than 300 years as a result of material behavior, tectonic events, etc. As a result, very little, if any, confidence can be placed on the engineered-barrier system.

REVIEWER: James F. Thompson



Signature

ORGANIZATION: Thompson Eng.

DATE: 06/19/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 116 CHAPTER NO.: 8

SEC. NO.: 8.0 PAGE. NO.: 8 FIG./TABL:

COMMENT

With regard to the engineered-barrier system, the DOE has chosen to focus on three subjects at hand:

1. The air gap between the container and the rock.

2. The container.

3. The waste form.

First, the air gap is really not an engineered-barrier. Secondly, much concern is given towards the repository as a whole, namely, the arrangement of the drifts, shafts, and ramps; the thermal design of the repository layout; the design and construction of all planned seals and plugs; etc.

REVIEWER: James F. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06/19/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 117 CHAPTER NO.: 8

SEC. NO.: 8.0 PAGE. NO.: 8 FIG./TABL:

COMMENT

Many statements are made to the tremendous time required for waste migration or water flux through the unsaturated zone. Such statements, if the flow predominately occurs through fractures, may prove false. Of concern is that not enough time exists for site characterization to prove or verify these travel times. Such tests simply require more time than is allowed within the program.

REVIEWER: James F. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06/19/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 118 CHAPTER NO.: 8

SEC. NO.: 8.0 PAGE. NO.: 9 FIG./TABL:

COMMENT

It is stated that the design of the repository is such that the repository itself will be able to withstand the expected seismic events in the Yucca Mountain region. It can be agreed that the repository will be able to remain functional as a normal "mining" facility after an extreme seismic event, but the engineered-barrier will very possibly fail. Seals and plugs may crack and the containers themselves may become damaged given a nominal seismic event. As a result, the engineered-barrier may be rendered useless.

REVIEWER: James F. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06/19/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 119 CHAPTER NO.: 8

SEC. NO.: 8.0 PAGE. NO.: 9 FIG./TABL:

COMMENT

The SCP does state the priorities of the site characterization activities in this section, and it can be agreed that the priorities of the program are reasonably sound. However, of serious concern is that it is already assumed by the DOE that the site is suitable for a repository and that not enough time exists under the current schedule to fully test and evaluate the site. Such experiments and evaluations (such as within the unsaturated zone) really require a substantial amount of time: far greater than what is currently being allowed.

REVIEWER: James F. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06/19/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 120 CHAPTER NO.: 8

SEC. NO.: 8.1.2.3 PAGE. NO.: 11 FIG./TABL:

COMMENT

It is a point well taken that the site characterization program is extremely complex and comprehensive; still, some measure of performance assessment should be required. It is difficult to understand the logic behind the suggestion that the program elements would be evaluated individually with respect to adequacy of information obtained, when it is well known that the repository elements behave as coupled processes.

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 121 CHAPTER NO.: 8

SEC. NO.: 8.3.1.1 PAGE. NO.: 4 FIG./TABL:

COMMENT

It is true that various geologic processes observed at Yucca Mountain has been observed elsewhere. The main point, however, is not presenting these processes as common place but to address the issue of whether the combination of processes adversely affect the integrity and licensibility of the site to contain high-level nuclear waste.

REVIEWER: Philip Murphy

Signature

ORGANIZATION: Dunn

DATE: 6-08-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: AUTHOR: DOE

COMMENT NO.: 122 CHAPTER NO.: 8

SEC. NO.: 8.3.1.1 PAGE. NO.: 4 FIG./TABL:

COMMENT

I am not certain what is meant by the statement "In general, knowledge of the geologic setting constrains and provides confidence in local interpretations." Knowledge of the geologic setting provides hypotheses which can provide avenues of additional research for resolution or clarification. The more information there is, the narrower the interpretation and the greater the agreement.

REVIEWER: Philip Murphy

Signature

ORGANIZATION: Dunn

DATE: 6/8/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 123 CHAPTER NO.: 8

SEC. NO.: 8.3.1.2 PAGE. NO.: 4 FIG./TABL:

COMMENT

The top paragraph on this page states that untried and nonstandard approaches must be taken because of the inherently poor understanding of the hydrologic processes in thick, arid-region, fractured-rock unsaturated zones. It would be best to pursue these untried and nonstandard approaches separately from the SCP and to propose only those which are found to be applicable in resolving questions related to acceptability of the site. This would take more calendar time, but would result in the accumulation of reliable data upon which final decisions can be made without encumbering the record with false starts, unacceptable data, and incorrect conclusions.

REVIEWER: MERVIN L. KLUG

Mervin L. Klug
Signature

ORGANIZATION: GUYTON ASSOCIATES

DATE: 5-31-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 124 CHAPTER NO.: 8

SEC. NO.: 8.3.1.2 PAGE. NO.: 5 FIG./TABL: 8.3.1.2-1

COMMENT

8.3.1.2-1

The middle box should have at least the following added to it

2.0 Required statistical parameters for evaluation to determine if the data can be depended upon.

The lower box requires at least:

8.3.1.18 Evaluation of the statistical variance of parameters on the final conclusions

REVIEWER: H.E. Skibitzke

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 125 CHAPTER NO.: 8

SEC. NO.: 8.3.1.2 PAGE. NO.: 7 FIG./TABL: 8.3.1.2-3

COMMENT

The problem of dispersive properties depends on the heterogeneity of the aquifer materials. There are no arrangements in the following pages to measure and analyze this functional control. After dispersion over a 1000 years the movement of the ground water as a carrier will be different, after encountering the heterogenous state of the aquifer, then would be a simple Darcian concept. Further ground water movement is only a carrier with a continually changing system of movement.

REVIEWER: H.E. Skibitzke

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 126 CHAPTER NO.: 8

SEC. NO.: 8.3.1.2 PAGE. NO.: 49 FIG./TABL:

COMMENT

The second and third paragraphs discuss applying multiple approaches to determining parameters not readily amenable to measurement or analysis, and to measure a parameter at different scales. I agree with this concept of developing confidence levels as long as the approaches have been proven acceptable and do not reflect experimental or untried procedures.

REVIEWER: MERVIN L. KLUG

Mervin L. Klug
Signature

ORGANIZATION: GUYTON ASSOCIATES

DATE: 5-31-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 127 CHAPTER NO.: 8

SEC. NO.: 8.3.1.2 PAGE. NO.: 52 FIG./TABL:

COMMENT

The low rating for reducing uncertainty with regard to stratigraphy in Column 8 does not appear appropriate. Vertical coupling between stratigraphic units could destroy their ability to function as discrete hydrographic units as indicated in Column 3. If the sensitivity to alternate hypotheses is high as shown in Column 7 due to the bearing it has on calculating GWTT and radionuclide releases to the accessible environment, it is difficult to understand how using statistical methods based on completely random systems can produce results having a high confidence level. Thus, the need to reduce uncertainty should be shown as high in Column 8.

REVIEWER: MERVIN L. KLUG

Mervin L. Klug
Signature

ORGANIZATION: GUYTON ASSOCIATES

DATE: 5-31-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 128 CHAPTER NO.: 8

SEC. NO.: 8.3.1.2.1 PAGE. NO.: 96 FIG./TABL:

COMMENT

Third Paragraph describes the fact that precipitation cannot be synthesized. But the hope of a data collection program doing so is hard to conceive since a period of about 50 years would be required. It is fortunate that precipitation data would not be necessary since its accuracy makes it irrelevant.

REVIEWER: H.E. Skibitzke

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: AUTHOR: DOE

COMMENT NO.: 129 CHAPTER NO.: 8

SEC. NO.: 8.3.1.2.1 PAGE. NO.: 97 FIG./TABL:

COMMENT

Preferential recharge can also take place through fractures or fracture zones as well as faults. The infiltration model should take this into account.

REVIEWER: Philip Murphy

Philip Murphy
Signature

ORGANIZATION: Dunn

DATE: 6/8/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: AUTHOR: DOE

COMMENT NO.: 130 CHAPTER NO.: 8

SEC. NO.: 8.3.1.2.1.2.2 PAGE. NO.: 113 FIG./TABL:

COMMENT

Based on the site plan shown of Figure 6-12, a more careful examination now of the possible paths of debris flow can help in modifying the diversion structures and road courses to minimize damage resulting from debris flows.

REVIEWER: Philip Murphy

Signature

ORGANIZATION: Dunn

DATE: 6/8/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: AUTHOR: DOE

COMMENT NO.: 131 CHAPTER NO.: 8

SEC. NO.: 8.3.1.2.1.3 PAGE. NO.: 116 FIG./TABL:

COMMENT

Given the lack of knowledge about the Paleozoic carbonate rock, the deepening of USW WT-21 and WT-22 and the drilling of another hole, possibly upgradient of the site should be a certainty. The computer model will only yield results based on the input which should be as factual as reasonably possible.

REVIEWER: Philip Murphy

Philip Murphy
Signature

ORGANIZATION: Dunn

DATE: 6/8/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: AUTHOR: DOE

COMMENT NO.: 132 CHAPTER NO.: 8

SEC. NO.: 8.3.1.2.1.3 PAGE. NO.: 116 FIG./TABL:

COMMENT

A drillhole constructed into the Paleozoic units would not be able to yield information on direction of groundwater flow by itself. This information must be related with other holes or to other newly drilled holes.

REVIEWER: Philip Murphy

Philip Murphy
Signature

ORGANIZATION: Dunn

DATE: 6/8/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 133 CHAPTER NO.: 8

SEC. NO.: 8.3.1.2.1.3.2 PAGE. NO.: 118 FIG./TABL:

COMMENT

The last paragraph states that a general field reconnaissance will be conducted to locate previously unknown or unobserved wells, springs, and mine shafts that may yield information about regional ground-water levels. I fully agree with this. However, I am surprised this has not already been done. One of the first steps of a ground-water investigation is to collect all available data, including the making of a field inventory such as this. It appears the information would have been of value in the preparation of this SCP.

REVIEWER: MERVIN L. KLUG

Mervin L. Klug
Signature

ORGANIZATION: GUYTON ASSOCIATES

DATE: 5-31-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 134 CHAPTER NO.: 8

SEC. NO.: 8.3.1.2.1.3.2 PAGE. NO.: 120 FIG./TABL:

COMMENT

Reference is made to a Figure 3-1 in the third paragraph on this page. This illustration was not included in the SCP, or if so, it was not properly identified. A similar problem exists with regard to Figure 3-28 referred to in the last paragraph on this page, and earlier with reference to Figure 3-3 in the next to the last paragraph on Page 8.3.1.2-105.

REVIEWER: MERVIN L. KLUG

Mervin L. Klug
Signature

ORGANIZATION: GUYTON ASSOCIATES

DATE: 5-31-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: AUTHOR: DOE

COMMENT NO.: 135 CHAPTER NO.: 8

SEC. NO.: 8.3.1.2.1.3 PAGE. NO.: 120 FIG./TABL:

COMMENT

Standard geophysical logs and examination of cuttings do not yield any quantitative determination of permeability. A qualitative determination can be made using spontaneous potential and a petrographic study of the cuttings.

REVIEWER: Philip Murphy

Signature

ORGANIZATION: Dunn

DATE: 6/8/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 136 CHAPTER NO.: 8

SEC. NO.: 8.3.1.2.1.3.3 PAGE. NO.: 127 FIG./TABL:

COMMENT

The third and fourth paragraphs talk about drill holes for monitoring to estimate recharge along Fortymile Wash. The drill holes as shown by Figure 8.3.1.2-9 are apparently located along the wash, which means that only that portion of the recharge that moves directly downward will be monitored. It is possible that recharge moving downward through the alluvium will encounter bedrock and move laterally down-dip to fractures, faults, or other openings where it can again move downward. Thus, it would be desirable to have some offset drill holes to check on this possibility and provide control for determining the mechanics of recharge that might occur along the wash.

REVIEWER: MERVIN L. KLUG

Mervin L. Klug
Signature

ORGANIZATION: GUYTON ASSOCIATES

DATE: 5-31-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 137 CHAPTER NO.: 8

SEC. NO.: 8.3.1.2.2 PAGE. NO.: 150 FIG./TABL:

COMMENT

The first full paragraph on this page talks about technical rationale for the investigation and says that prototype studies will be conducted. These prototype studies are not to be part of the site characterization investigation, but will be done to determine what can be done in an effort to characterize conditions at the site. These prototype studies are necessary, but they should already have been performed so the results could be reflected in the present SCP document. It might be difficult to integrate them into the SCP later on or to apply the results in a timely manner for reaching decisions about the adequacy of the proposed repository.

REVIEWER: MERVIN L. KLUG

Mervin L. Klug
Signature

ORGANIZATION: GUYTON ASSOCIATES

DATE: 5-31-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: AUTHOR: DOE

COMMENT NO.: 138 CHAPTER NO.: 8

SEC. NO.: 8.3.1.2.2 PAGE. NO.: 151 FIG./TABL:

COMMENT

A sequence of non-welded porous tuffs overlie the Topopah Springs Member probably forming a natural capillary barrier to retard the entrance of transient pulses of water into fractured tuffs. The state of knowledge of the site, however, does not preclude the possibility of an unmapped fault or fracture zone negating this conclusion.

REVIEWER: Philip Murphy

Signature

ORGANIZATION: Dunn

DATE: 6/8/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: AUTHOR: DOE

COMMENT NO.: 139 CHAPTER NO.: 8

SEC. NO.: 8.3.1.2.2.3.3 PAGE. NO.: 223 FIG./TABL:

COMMENT

It is very difficult to run geophysical/video equipment into a horizontal hole. The 2-3 degree inclination would not be sufficient to overcome inertia and frictional forces and obtain readings through the entire length of the hole.

REVIEWER: Philip Murphy

Signature

ORGANIZATION: Dunn

DATE: 6/8/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 140 CHAPTER NO.: 8

SEC. NO.: 8.3.1.2.2.4.3 PAGE. NO.: 274 FIG./TABL:

COMMENT

The modeling of the repository horizon for permeability based on the results of air pressure should account for the difference in viscosity between air and water. The value of permeability of the rock with respect to water should be lower than that for air.

REVIEWER: Philip Murphy

Signature

ORGANIZATION: Dunn

DATE: 6-08-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 141 CHAPTER NO.: 8

SEC. NO.: 8.3.1.2.2.4.10 PAGE. NO.: 318 FIG./TABL:

COMMENT

Any core taken for the purposes of measuring ambient moisture conditions will be subjected to heat and pressurized air mixed with a tracer. The heat will vaporize the natural moisture which will combine with the "tagged" air used in drilling. The tracer will be found in all samples, and especially in the smaller sized cuttings. The presence of tracer gas does not always indicate moisture.

REVIEWER: Philip Murphy

Signature

ORGANIZATION: Dunn

DATE: 06-09-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 142 CHAPTER NO.: 8

SEC. NO.: 8.3.1.2.2.9.1 PAGE. NO.: 351 FIG./TABL:

COMMENT

The spatial distributions of the Parameters cited can only be statistical variables. The process of determining them should be so oriented. If at best the data are unreliable by a statistical analyses we should know it and plan accordingly.

Sampling sites will be expensive, there is no doubt, and accordingly data will be limited and expensive. However if it does not meet criterion for value in predictive analyses then we should acknowledge it and not ignore the fact or coverup the possible consequences. Data also can be irrelevant to the projected predictions even though we can measure it today.

REVIEWER: H.E. Skibitzke

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP Review
DOCUMENT NO.: DOE/RW-199 AUTHOR: NONE

COMMENT NO.: 143 CHAPTER NO.: 8

SEC. NO.: 8.3.1.2.2.10 PAGE. NO.: 362 FIG./TABL:

COMMENT

The most important consideration here is an anlysis of variances of the output data. Much of the data will be misleading to use without such an analysis. An analysis to determine the future data collection based on current needs is required. This will include an evaluation of the data requirements to reduce the standard deviation to a required figure. This figure should be explicitly decided. We must consider that the statistical variations are variations having a geometric function so that space is a variable. I believe that to fit the regulatory requirements of 40 CFR and 20 CFR a confidence interval must be set for each step in the process. Each step in the process should then be evaluated for how its accuracy will effect the final value. This is true since it is impossible to come up with a completely true result just how far can the result be from certainty. Is this acceptable in light of the legislative criterion. It probably will not be. What action to take is not then a technical problem instead it's a legal question.

REVIEWER: H.E. Skibitzke

Signature

ORGANIZATION: SEA

DATE: 5/30/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 144 CHAPTER NO.: 8

SEC. NO.: 8.3.1.2.3.1.5 PAGE. NO.: 403 FIG./TABL:

COMMENT

During drilling operations in the bedded salt deposits of the Texas Panhandle a tracer was added to the drilling fluids so the natural water and the fluids introduced by drilling could be distinguished. The wells were pumped but the tracer concentration in the samples never reached zero. Graphically the concentration asymptotically approached zero. The pumping may take longer than 4 weeks.

REVIEWER: Philip Murphy

Signature

ORGANIZATION: Dunn

DATE: 6-09-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 145 CHAPTER NO.: 8

SEC. NO.: 8.3.1.2.4 PAGE. NO.: 446 FIG./TABL: 8.3.1.2-32

COMMENT

This figure presents a schedule for the major events involved in site characterization. Very little is known about the geohydrologic system at Yucca Mountain after years of study by people involved in the project as well as by others associated with state and federal projects in the region. In view of the unknowns that are acknowledged, it is hard to conceive how sufficient and adequate data can be obtained and evaluated by 1995 for reaching decisions regarding the acceptability of the Yucca Mountain site as a repository for high-level nuclear wastes. This is less than 6 years from now. It appears construction of ES-1 should not begin until all the methods and related procedures proposed for characterizing geohydrology have been established.

REVIEWER: MERVIN L. KLUG

Mervin L. Klug
Signature

ORGANIZATION: GUYTON ASSOCIATES

DATE: 5-31-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 146 CHAPTER NO.: 8

SEC. NO.: 8.3.1.4.2 PAGE. NO.: 31 FIG./TABL:

COMMENT

Characterization of the vertical component of fractures can also be investigated by boring at an angle to the vertical. Close control would be needed during drilling to prevent excessive deviation of the hole from the planned angle.

REVIEWER: Philip Murphy

Signature

ORGANIZATION: Dunn

DATE: 6-09-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 147 CHAPTER NO.: 8

SEC. NO.: 8.3.2.1 PAGE. NO.: 1 FIG./TABL:

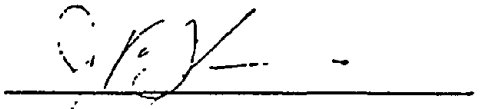
COMMENT

The repository is planned to be designed (final design) and constructed in a phased manner. In other words, construction may begin on the site preparation while designs are being reviewed and approved for the underground networks, for example. This is not an unusual form of design\construction; however, as a result, the NRC, State of Nevada, and other overview entities will not have fully complete information in terms of design and construction documents before them while conducting reviews, etc.

It would certainly be preferable (although impossible in terms of the given time frame) to have a complete set of plans, specifications, and estimates, such that a complete review could be made of the ESF and the planned repository.

Due to the lack of complete information, the overview entities may not be able to fully access and review the planned construction activities.

REVIEWER: James F. Thompson



Signature

ORGANIZATION: Thompson Eng.

DATE: 06/19/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 148 CHAPTER NO.: 8

SEC. NO.: 8.3.2.1 PAGE. NO.: 1 FIG./TABL:

COMMENT

It is stated that the design of the repository shall be such that the option to retrieve the waste be maintained until the license amendment for permanent closure is granted. What is important to note, is that whatever makes the repository unfit for closure licensing, may also cause retrieval to be impossible.

For example, given some form of catastrophic failure of a canister (ie. corrosion, tectonic event, etc.), it may be impossible to retrieve the waste due to human risk during retrieval.

REVIEWER: James F. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06/19/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

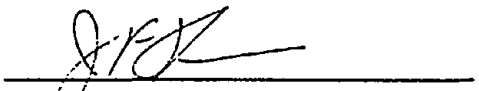
COMMENT NO.: 149 CHAPTER NO.: 8

SEC. NO.: 8.3.2.1 PAGE. NO.: 7 FIG./TABL:

COMMENT

Given the various design phases for the repository, it is unclear as to what interaction is given to the data obtained during site characterization with respect to design input. Much of the testing and studies conducted during the SCP is very important to the final design of the repository; yet, it is not clearly stated how the design of the repository will interact with the data obtained during the testing activities of site characterization.

REVIEWER: James F. Thompson



, Signature

ORGANIZATION: Thompson Eng.

DATE: 06/19/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 150 CHAPTER NO.: 8

SEC. NO.: 8.3.2.1 PAGE. NO.: 13 FIG./TABL:

COMMENT

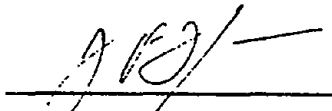
Discussions are made in this section of the SCP about the potential coupled processes that could occur within a repository. They have listed five general classes of processes that may in turn be coupled. These five classes are as follows:

1. Thermal
2. Hydrologic
3. Mechanical
4. Chemical
5. Radiological

It is admitted within the SCP that the reactions between these five processes can be tremendous under a given set of conditions and constraints. What is disturbing is that it is stated that since the number of processes can be very large, "Testing will, therefore, occur only if it is relevant to licensing arguments."

This puts a great deal of weight on the licensing arguments in terms of regional safety of the repository program. In other words, it should not be assumed that the licensing requirements have covered all of the potentially hazardous events that could occur.

REVIEWER: James F. Thompson



Signature

ORGANIZATION: Thompson Eng.

DATE: 06/19/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 151 CHAPTER NO.: 8

SEC. NO.: 8.3.2.1 PAGE. NO.: 18 FIG./TABL:

COMMENT

It is disturbing that as stated in the SCP, "the goal of the Yucca Mountain Project is not an optimum design solution, but a design that has been optimized ...."

It is my opinion that the goal of this project is not to achieve only an "acceptable" design, but an optimum design. This form of goal, that the DOE has established, may very well be related to the phased construction/design proposed. After all, it may very well be impossible to achieve an optimum solution or design when not given proper site specific data to begin with. But, this could be an argument not to begin any detailed design of the repository until after all of the site characterization activities are completed and validated.

REVIEWER: James F. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06/19/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 152 CHAPTER NO.: 8

SEC. NO.: 8.3.2.1 PAGE. NO.: 19 FIG./TABL:

COMMENT

It is understood that the design of the ESF and the repository will change or evolve as more site specific data are obtained; however, it is unclear as to the mechanism by which these design changes are employed. Of concern is that not enough input will be facilitated from both the NRC and the State during these design changes while construction is underway.

REVIEWER: James F. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06/19/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 153 CHAPTER NO.: 8

SEC. NO.: 8.3.2.1.2 PAGE. NO.: 13 FIG./TABL:

COMMENT

The controlling argument for conducting coupled interaction tests should be their relevancy to the repository design as well as to licensing.

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 154 CHAPTER NO.: 8

SEC. NO.: 8.3.2.1.3 PAGE. NO.: 18 FIG./TABL:

COMMENT

The fifth (5th) paragraph of Section 8.3.2.1.3 titled "Design Improvement Activities and Tests" states "In arriving at a design with the preceding attributes, many trade off analyses will be required." Further into the paragraph it also states "cost and performance may also be traded off for each of the design choices."

As engineers, we all recognize the potential of having to consider trade offs in design, however, it concerns me that a project of this criticality has a written statement acknowledging the possibility of cost and performance trade offs without elaboration. I would suggest the site characterization plan statement is meant to say "low cost may have to be sacrificed for a higher performance design."

REVIEWER: W. D. Huff

Signature

ORGANIZATION: Thompson Eng.

DATE: 05-24-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 155 CHAPTER NO.: 8

SEC. NO.: 8.3.2.1.4.1 PAGE. NO.: 23 FIG./TABL:

COMMENT

There should be an effort to use finite-element techniques to analyze the thermomechanical processes as interactively coupled phenomenon instead of conducting the analysis of the processes in question as two separate events.

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 156 CHAPTER NO.: 8

SEC. NO.: 8.3.2.1.4.1 PAGE. NO.: 1 FIG./TABL:

COMMENT

Performing multivariable interaction tests is relevant to licensing arguments only if performing those tests is necessary to characterize behavior to show compliance with regulatory criteria. If the investigation of any particular combination of processes does not aid in showing compliance with at least one regulatory criterion, then that investigation is not relevant, and testing to determine the behavior and effects of those coupled processes is not necessary.

The regulatory criteria was established 10 years ago and this is the first repository proposed. A possible investigation should not be ruled out automatically if it does not aid in showing compliance with the original regulatory criterion. It may address a significant consideration that was previously overlooked due to inexperience.

REVIEWER: Colleen R. Stout

Colleen Raye Stout
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 157 CHAPTER NO.: 8

SEC. NO.: 8.3.2.1.4.3 PAGE. NO.: 1 FIG./TABL:

COMMENT

The effects of condensation (or sweating) on the permeability of the rock walls exposed to the ventilation system is not proposed to be considered or tested. Such considerations may prove useful.

REVIEWER: Colleen R. Stout

Colleen Raye Stout
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 158 CHAPTER NO.: 8

SEC. NO.: 8.3.2.5.7 PAGE. NO.: 69 FIG./TABL:

COMMENT

There is a need to address the fact that the tunnel index methods employed in the underground repository facilities' structural-thermal analysis do not account for the effects of heat.

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 159 CHAPTER NO.: 8

SEC. NO.: 8.3.2.5.7 PAGE. NO.: 69 FIG./TABL:

COMMENT

Even though the method for the empirical structural design of the shafts and ramps have not been selected, an outline of the methods under consideration should be included. Also, impact assessment of the possible design methods on the design of the repository's subsystems should be given consideration.

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi

Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOe

COMMENT NO.: 160 CHAPTER NO.: 8

SEC. NO.: 8.3.2.5.7 PAGE. NO.: 71 FIG./TABL:

COMMENT

There is a need to address the possibility that the empirical design methods for the drifts would not be able to simulate or incorporate the thermal effects and the impact of such possibility on the overall direction of the program.

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi

Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 198 CHAPTER NO.: 8

SEC. NO.: 8.4.2 PAGE. NO.: 188 FIG./TABL:

COMMENT

It is stated that the shaft liners will be unreinforced, although no justification for this action is given (it is assumed to ease removal of the liner). Several problems arise with the construction of the liner without any reinforcing:

1. This is in violation of the ACI code pertaining to such designs.

2. No reinforcement can allow for much shrinkage and resultant cracking depending on the mix design.

3. A round opening, such as the shaft, can be considered to have a uniform loading (such a loading may not even exist in this environment). Under this loading scenario, each section of the liner will be in compression. However, during a seismic event, differential deformation or loading may take place that would cause some faces of the liner to be in tension. With no reinforcement, a structural failure would be likely since concrete has very little tension strength.

REVIEWER: James F. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06/21/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 197 CHAPTER NO.: 8

SEC. NO.: 8.4.2 PAGE. NO.: 169 FIG./TABL:

COMMENT

The statement that the "surface topography allows proper drainage" may prove false given the uncertain hydrologic history at Yucca Mountain. In addition, without proper modeling of the improvements proposed within the wash, it cannot be concluded that no danger of surface flooding exists.

REVIEWER: James F. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06/21/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 196 CHAPTER NO.: 8

SEC. NO.: 8.4.2 PAGE. NO.: 167 FIG./TABL:

COMMENT

As noted within this section of the SCP, only one hoist house has been planned for both shafts. It would seem prudent to have two hoist houses to account or facilitate fire protection. This would aid in the assurance that at least one shaft could remain operational in the event of a fire.

REVIEWER: James F. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06/21/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 195 CHAPTER NO.: 8

SEC. NO.: 8.4.2 PAGE. NO.: 153 FIG./TABL:

COMMENT

While it is stated that reports, plans, and specifications are in the various stages of preparation for the ESF, no mention is made of the vital calculations used for the design of the ESF. While it is true that the NRC and the State of Nevada are involved with the technical review of the ESF, this review cannot be made complete without the detailed calculations that were performed to determine the details of the design.

To date, the reports and plans provided to the State have not yielded sufficient information to form any solid conclusions.

REVIEWER: James F. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06/21/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 194 CHAPTER NO.: 8

SEC. NO.: 8.4.2 PAGE. NO.: 151 FIG./TABL:

COMMENT

The ESF will eventually become a part of the repository (if the repository is constructed), and therefore, the ESF should be designed, licensed, and constructed under the same rigorous constraints as the repository itself. As such, it is questionable, due to the whole purpose of the ESF (a means of obtaining site specific data), that the ESF will be able to be designed and constructed with the same degree of confidence as the repository in terms of waste isolation. This is really not a function of "design control;" but rather, a function of the fact that pertinent site specific data is not available for the design and construction of the ESF.

REVIEWER: James F. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06/21/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

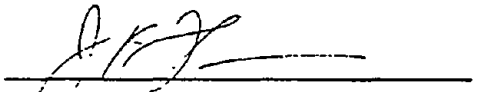
COMMENT NO.: 193 CHAPTER NO.: 8

SEC. NO.: 8.4.2 PAGE. NO.: 25 FIG./TABL:

COMMENT

With respect to the ESF location, discussions are made referring to the Bertram report and the five alternative ESF sites. It should be noted that the methodologies, as outlined in the Bertram report, used to "screen" the Yucca Mountain site, may not be fully agreed with. As a result, it is not assumed, as the SCP does, that the five alternate sites are the best potential sites within the repository block.

REVIEWER: James F. Thompson



Signature

ORGANIZATION: Thompson Eng.

DATE: 06/21/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 192 CHAPTER NO.: 8

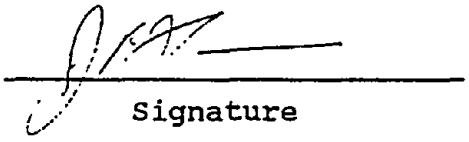
SEC. NO.: 8.4.1 PAGE. NO.: 21 FIG./TABL:

COMMENT

In conclusion of this section (8.4.1), I was pleased to find the preparers of this section discuss the fundamental concepts of their assumptions and hypotheses pertaining to the hydrogeologic regime at Yucca Mountain. While all of these assumptions and hypotheses may not be agreed with, the frank manner in which the information was presented was appreciated.

This section concludes that it will be extremely important to access the hydrogeologic setting at Yucca Mountain during site characterization activities; yet, as stated previously, it is questionable if adequate data can be obtained given the relatively short time frame allowed for testing. In essence, the assumptions made may not be able to be verified.

REVIEWER: James F. Thompson



Signature

ORGANIZATION: Thompson Eng.

DATE: 06/21/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 191 CHAPTER NO.: 8

SEC. NO.: 8.4.1 PAGE. NO.: 18 FIG./TABL:

COMMENT

"... water movement in fractures may occur at sporadic locations where local saturations in the matrix material are high. While this sporadic flow in fractures may occur, the predominant flow in the unsaturated zone probably is through the matrix."

Considering one of the primary issues of the repository is to assess the potentially shortest time for waste migration to the accessible environment, it could be concluded that even if the flux at Yucca Mountain is predominantly through the matrix, the fastest path of migration would result from flow through fractures. As a result, the emphasis on fracture flow should not be belittled.

REVIEWER: James F. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06/21/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 190 CHAPTER NO.: 8

SEC. NO.: 8.4.1 PAGE. NO.: 16 FIG./TABL:

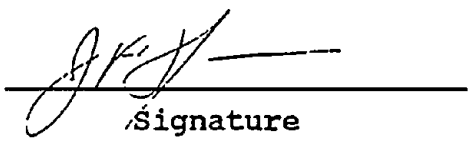
COMMENT

The first paragraph of this page concludes with a good discussion or rationale pertaining to water movement within the matrix in the unsaturated zone. Their following conclusion may be generally agreed with:

"Water stored within an unsaturated rock mass, therefore, would not be expected to move spontaneously into boreholes, drifts, shafts ..., or other openings whose diameters exceed the sizes of the pores. Movement into large openings requires additional external energy to initiate a transient change capable of causing such movement, such as increased infiltration or local heterogeneities and geometries that result in focused flow."

Since periodic increased infiltration rates are expected, and that the site as a whole is extremely heterogeneous, then it could logically be concluded that water will be expected to flow through fractures and into shafts, drifts, etc.

REVIEWER: James F. Thompson



Signature

ORGANIZATION: Thompson Eng.

DATE: 06/21/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 189 CHAPTER NO.: 8

SEC. NO.: 8.4.1 PAGE. NO.: 14 FIG./TABL:

COMMENT

Once again, it appears that a great deal of value is placed on the ability of the backfilled material to properly seal (in conjunction with the plugs) the shafts from surface water. The backfilled material may prove to hinder gaseous and vapor flow, but liquid flow may only be slightly effected. It appears premature to conclude that "water entering the backfill would be expected to be imbibed into the rock matrix."

REVIEWER: James F. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06/21/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 188 CHAPTER NO.: 8

SEC. NO.: 8.4.1 PAGE. NO.: 14 FIG./TABL:

COMMENT

Many of the hypotheses discussed herein are very sound in terms of technical integrity as related to the site characterization program. However, it is very important to note that one of the main underlying assumptions is that the hydraulic flux at Yucca Mountain predominately occurs through the rock matrix and not through fractures. If this is invalid, as it may very well be, then many of the discussions within this section lead to erroneous conclusions.

REVIEWER: James F. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06/21/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 187 CHAPTER NO.: 8

SEC. NO.: 8.4.1 PAGE. NO.: 13 FIG./TABL:

COMMENT

As a result of the blast damaged zone around the openings in the ESF, increased flux may result from the creation of preferential pathways. The relationship between increased flux and preferential pathways is not an either/or situation.

REVIEWER: James F. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06/21/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 186 CHAPTER NO.: 8

SEC. NO.: 8.4.1 PAGE. NO.: 2 FIG./TABL:

COMMENT

It is stated that as site characterization proceeds (especially with the ESF), the site specific data obtained will be utilized to modify the design and construction techniques employed. What is important to note, is that insufficient time exists from which to draw accurate conclusions about such site specific information, such as the hydraulic conductivity of the host rock. Such tests and evaluations take a very long time; and as such, it is questionable as to how much site specific data will be obtained that will effect the design and construction of the ESF, for example.

REVIEWER: James F. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06/21/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 185 CHAPTER NO.: 8

SEC. NO.: 8.4 PAGE. NO.: 1 FIG./TABL: 8.4.1-3

COMMENT

The principal objectives, as specified for the technical criteria from 10CFR, do not include design consideration or protection from intential accidents, explosions, or sabotage. Nor is it discussed as a consideration for Human Interference (Section 8.3.1.9) or Accidental Radiological Releases (Section 8.3.5.5).

REVIEWER: Colleen R. Stout

Colleen Rae Stout
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-15-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-1099 AUTHOR: DOE

COMMENT NO.: 184 CHAPTER NO.: 8

SEC. NO.: 8.4 PAGE. NO.: 1 FIG./TABL: 8.4.1-2

COMMENT

One of the postclosure performance objectives is to locate the repository so that prewaste emplacement groundwater travel time along fastest path of likely radionuclide travel from disturbed zone to accessible environment is at least 1,000 years, and the waste-package containers are designed for 300 to 1000 years. The lifetime expectency of the repository is 10,000 years. Therefore, it is inferred that there is potential for hazardous radionuclides to reach the environment as allowed by the performance objectives.

REVIEWER: Colleen R. Stout

Colleen Rae Stout
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-15-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 183 CHAPTER NO.: 8

SEC. NO.: 8.3.5.13 PAGE. NO.: 11 FIG./TABL:

COMMENT

The Cranwell methodology presented on Page 11 represents the CCDF as a weighted sum of conditional CCDF's. Using the mathematical notation developed in the background material, equation (2) of Hunter et al. (1986) reads:

$$G(m) = \Sigma_j \; G(m/s_j) \; P(s_j) \qquad (8.3.5.13\text{-}6)$$

where:

S_j = A Designator for the jth "Scenario"

The discussion then goes on to say:

"Scenario is placed in quotation marks in the above definitions because the Cranwell methodology definition of the term apparently includes objects that are more general than the objects defined by this section's definition of scenario; the intended meaning of Hunter et al. (1986) appears to be closer to the term "scenario class"."

The use of the words "apparently," "intented," and "appears" in the above paragraph do not instill confidence in the reader that the formula is confidently understood.

REVIEWER: W. D. Huff

Signature

ORGANIZATION: Thompson Eng.

DATE: 05-30-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 182 CHAPTER NO.: 8

SEC. NO.: 8.3.5.11 PAGE. NO.: 4 FIG./TABL:

COMMENT

A disappointment with the SCP is that little information is given pertaining to the results of tests conducted on the proposed seal materials, such as expansive cements. Los Alamos has published several documents recently which yield a tremendous amount of good information pertaining to the behavior of such cementious materials (see other coments), but little appears to have been addressed within the SCP. After reviewing these other documents, it becomes quickly apparent that many of the proposed designs and materials will not function as planned (i.e. cements not having the expected expansion characteristics under high temperatures, etc.).

REVIEWER: James F. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06/20/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 181 CHAPTER NO.: 8

SEC. NO.: 8.3.5.9 PAGE. NO.: 12 FIG./TABL:

COMMENT

It is stated in this section of the SCP that the heat generated by the waste will "raise the temperature of the host rock above the local boiling point of water" and will remain at that point for hundreds of years. This may indeed "dry out" much of the repository area, but of concern is this effect on the rock mass behavior and on the issue of retrievability itself. If, for whatever reason, retrieval is necessary, such high temperatures may make retrieval impossible.

REVIEWER: James F. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06/20/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 180 CHAPTER NO.: 8

SEC. NO.: 8.3.5.9 PAGE. NO.: 1 FIG./TABL:

COMMENT

An important question comes to mind as to the validity of the rationale used to arrive to the intended design life of the waste packages. We are left to wonder what to become of the waste packages after the 300 to 1000 yr. design life.

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi
Signature

ORGANIZATION: Thompson Engr.

DATE: 06-21-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 179 CHAPTER NO.: 8

SEC. NO.: 8.3.3.2.1 PAGE. NO.: 34 FIG./TABL:

COMMENT

There is still a requirement to develop and maintain an alternative parameter need for the other possible sealing material.

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi

Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 178 CHAPTER NO.: 8

SEC. NO.: 8.3.3.2 PAGE. NO.: 34 FIG./TABL:

COMMENT

An interesting aspect of the discussion related to the expected permeability of the fill material is related to a seismic event. An event of any nominal magnitude can have a significant effect on a granular fill. Once under vibration, the voids can be reduced or altered causing a redistribution of the flows within the fill. This is also related to the possibility of "excessive settlement" of the shaft fill.

REVIEWER: James F. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06/20/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 177 CHAPTER NO.: 8

SEC. NO.: 8.3.3.2 PAGE. NO.: 30 FIG./TABL:

COMMENT

In this section, it is stated that the ESF design and proposed construction methodology are intended to limit the uncertainties in three primary ways as listed. Listed below are comments to these three principals, respectively:

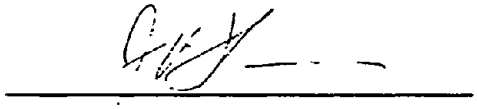
1. It can be argued that water inflow, due to infiltration and flooding, is a very potential problem as a result of the ESF being located in a wash.

2. Other construction methodologies would have a far better effect on controlling damaged zones than the blasting proposed.

3. The shaft liner, currently proposed to be unreinforced, may hinder the evaluation and testing of the rock permeability.

As a result, the conservatism employed is in question.

REVIEWER: James F. Thompson



Signature

ORGANIZATION: Thompson Eng.

DATE: 06/20/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 176 CHAPTER NO.: 8

SEC. NO.: 8.3.3.2 PAGE. NO.: 29 FIG./TABL:

COMMENT

From the discussions pertaining to the seals proposed within the repository, it is noted that much emphasis is put forth on "drainage." While this may prove prudent, it is interesting to note that a design goal is to "encourage vertical drainage of water through the drift floors."

As stated, this may be a good design goal; yet, the impacts of this performance on vertical emplacement may be severe. So severe, that the possibility of vertical emplacement may be dropped from further consideration.

REVIEWER: James F. Thompson

Signature

ORGANIZATION: Thompson Eng.

DATE: 06/20/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 175 CHAPTER NO.: 8

SEC. NO.: 8.3.3.2 PAGE. NO.: 29 FIG./TABL:

COMMENT

The constraint not to intersect the boreholes is contradictory to the overall design philosophy of the repository where the orientation and layout of the underground repository drifts dictated the location of the site characterization boreholes, as opposed to location of boreholes dictating and imposing a constraint on the layout of the repository. This statement should be revised to reflect, and be in line with, the general repository design philosophy.

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi

Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 174 CHAPTER NO.: 8

SEC. NO.: 8.3.3.2 PAGE. NO.: 27 FIG./TABL:

COMMENT

The need to evaluate the uncertainties in both the performance goals and estimates of anticipated and unanticipated inflows should have been addressed at this stage of site characterization.

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi

Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 173 CHAPTER NO.: 8

SEC. NO.: 8.3.3.2 PAGE. NO.: 26 FIG./TABL:

COMMENT

An assessment of the impact of the proposed design, after its development, not meeting regulatory requirements needs to be addressed. At this point, reference is made to the effect that the design "may have to be modified...," to meet these requirements, but neglects to address the issue that a modified design may not be attainable.

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi

Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 172 CHAPTER NO.: 8

SEC. NO.: 8.3.3.2 PAGE. NO.: 25 FIG./TABL:

COMMENT

Having multiple barriers with possible introduction of performance redundancy might not be such an undesirable feature. The degree and magnitude of redundancy desired is more aptly to be the issue of concern.

REVIEWER: Nahel F. Kabazi

Nahel F. Kabazi
Signature

ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 171 CHAPTER NO.: 8

SEC. NO.: 8.3.3.2 PAGE. NO.: 25 FIG./TABL:

COMMENT

With respect to the anchor-to-bedrock plug/seals, it is anticipated that these seals will reduce the amount of water that enters the emplacement drifts. If the seal will be a cementious material, such as concrete, as currently proposed, the shrinkage that will occur during hydration will cause a slight separation in places from the rock face. This is a normal phenomena and is typically expected. As water travels down the face of the shaft, adjacent to fill material, the seal or plug placed within the shaft may not hinder the water movement at all. This is why synthetic materials are utilized in conjuction with concrete plugs in underground structural design.

REVIEWER: James F. Thompson

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ORGANIZATION: Thompson Eng.

DATE: 06/19/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 170 CHAPTER NO.: 8

SEC. NO.: 8.3.3.2 PAGE. NO.: 11 FIG./TABL: 8.3.3.2-1

COMMENT

One of the sealing components listed is backfilled material. This is proposed to be comprised of the tuff removed during the original mining operations. It is not really accurate to consider this material a fill. While providing a possible beneficial drainage mechanism, this fill material will do little to hinder water migration. The permeability of the host rock will be dramatically different than that of the fill material.

REVIEWER: James F. Thompson

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DATE: 06/19/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 169 CHAPTER NO.: 8

SEC. NO.: 8.3.3.2 PAGE. NO.: 9 FIG./TABL: 8.3.3.2-1

COMMENT

This table identifies several sealing components and lists many factors associated with the seals. Of interest, is that one of the design goals is to limit the surface water intrusion to 1700 m^3/yr. from 0 to 500 years and 23000 m^3/yr., thereafter.

Contrary to the other sections of the SCP, this section is planning for the potential of a substantial amount of water moving through the repository block.

REVIEWER: James F. Thompson

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ORGANIZATION: Thompson Eng.

DATE: 06/19/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 168 CHAPTER NO.: 8

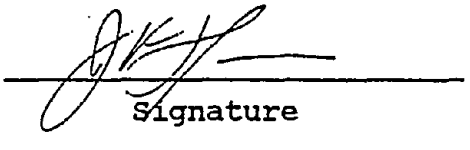
SEC. NO.: 8.3.3.2 PAGE. NO.: 7 FIG./TABL:

COMMENT

The seals and plugs proposed within the ESF and repository can be generally considered pertinent to the elimination or reduction of water entering the repository. One of the major mechanisms of this intrusion of water is from surface waters. The seals may prove to route water, especially water due to infiltration through regions that were unplanned and unexpected. This is not really a phenominal concept; yet, we should keep in mind that the seals and plugs of a repository, as stated in 10 CFR 60, are intended to generally pertain to repositories in the unsaturated zone.

If flows already exist in fractures, for example, a seal blocking that flow will cause a redistribution of the flows as the head builds within the fracture. As a result, new flow patterns may result that are more detrimental to waste isolation. Perhaps the solution to the concern with regard to the "seals" is to consider them more as drainage facilities - facilities that are designed and intended to route water away from the waste packages themselves and not seal them per se.

REVIEWER: James F. Thompson



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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 167 CHAPTER NO.: 8

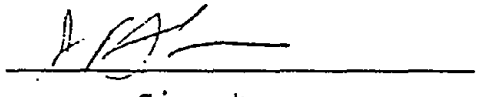
SEC. NO.: 8.3.3.2 PAGE. NO.: 6 FIG./TABL:

COMMENT

With regard to the seal materials utilized, the long-term effect of these seals given the various coupled processes at hand, may prove to be very difficult if not impossible to reasonably quantify.

Once again, the time frame allowed for such testing may not prove sufficient to accurately determine the adequacy of the sealing material and the resultant behavior of any seals proposed to be employed.

REVIEWER: James F. Thompson



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DATE: 06/19/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 166 CHAPTER NO.: 8

SEC. NO.: 8.3.3.2 PAGE. NO.: 1 FIG./TABL:

COMMENT

An interesting issue, with the discussion of the seals within the SCP, is the concept of ensuring the seals do not become preferential pathways for fluid movement. Arguments for or against the use of seals, types of materials, etc., should not be focused towards determining if the seals will become pathways, but rather on what effect the seals will have on creating or perturbating preferential pathways. After all, a seal itself will not become a preferential pathway, but as a result of its placement, a pathway may be created in an unknown/unplanned location.

REVIEWER: James F. Thompson

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ORGANIZATION: Thompson Eng.

DATE: 06/19/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 165 CHAPTER NO.: 8

SEC. NO.: 8.3.3.1.2 PAGE. NO.: 7 FIG./TABL:

COMMENT

A more precise definition of performance acceptability limits pertaining to the temperature effects on the proposed clay and portland cement sealing material is needed. Stating that the sealing material "...may perform acceptably to temperatures as high as 250° C...," does not instill confidence in the thought process employed to arrive to such an all encompassing conclusion.

REVIEWER: Nahel F. Kabazi

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ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 164 CHAPTER NO.: 8

SEC. NO.: 8.3.3.1 PAGE. NO.: 3 FIG./TABL:

COMMENT

The probability that a seal cannot be developed that will meet the established goals is a distinct possibility. In that event, the HLW would have to be recovered and a great deal of expense will have occurred without any substantial return. By moving forward the deadline for developing an effective seal, this expense can be greatly reduced.

REVIEWER: H. P. Thompson

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ORGANIZATION: Thompson Eng.

DATE: 6/21/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 163 CHAPTER NO.: 8

SEC. NO.: 8.3.3.1 PAGE. NO.: 1 FIG./TABL:

COMMENT

The delay of the seal installation until closure is questionable. There will be boreholes within the perimeter of the repository that penetrate the saturated tuff, and the depositing of HLW during the active placement period may require the sealing of these borehole penetrations prior to closing the repository.

REVIEWER: H. P. Thompson

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DATE: 6/21/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 162 CHAPTER NO.: 8

SEC. NO.: 8.3.2.5.8 PAGE. NO.: 85 FIG./TABL:

COMMENT

A precise definition of the level of reasonability concerning the availability of construction, operation, closure, and decommissioning technology is needed. Fiscal, cyclical as well as confidence limit bounds should be set as a frame for defining the acceptable level of so called "reasonable availability of technology."

REVIEWER: Nahel F. Kabazi

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ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 161 CHAPTER NO.: 8

SEC. NO.: 8.3.2.5.7 PAGE. NO.: 73 FIG./TABL:

COMMENT

By practically eliminating the current ventilation analyses computer codes, there is an obvious need to define and identify the analysis codes that will be used in the License Application phase of the project.

REVIEWER: Nahel F. Kabazi

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ORGANIZATION: Thompson Eng.

DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 199 CHAPTER NO.: 8

SEC. NO.: 8.4.2 PAGE. NO.: 205 FIG./TABL:

COMMENT

Much speculation is given to the elastic behavior of the rock mass. In previously published study plans, the blast damaged zone, for example, was expected to be limited to three times the diameter of the opening; yet, now this has evidently been changed to two times the diameter. No discussion is given to explain this change in design.

REVIEWER: James F. Thompson

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ORGANIZATION: Thompson Eng.

DATE: 06/23/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 200 CHAPTER NO.: 8

SEC. NO.: 8.4.2 PAGE. NO.: 205 FIG./TABL:

COMMENT

It is anticipated that elastic analysis will approximate the behavior of the rock mass. Due to the inherent mass characteristic of the rock, it is doubtful that an elastic analysis will accurately predict the behavior from a total system standpoint. It is even stated that "Where rock movement and loosening along joints was evident, measured displacements ranged from 3 to 10 times the predicted elastic displacements." Even after such a comment is made, the conclusion is made that "elastic analyses will provide good estimates of rock behavior near excavations."

REVIEWER: James F. Thompson

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DATE: 06/21/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 201 CHAPTER NO.: 8

SEC. NO.: 8.4.2 PAGE. NO.: 207 FIG./TABL:

COMMENT

The statement that "From this testing, the fractures were found to be tighter after excavation than before, in most places near the excavation," should not be misinterpreted to imply that the blasting conducted during excavation will have a positive effect on the permeability of the host rock. While some fractures will close or become "tighter" after excavation, many other fractures will be mitigated and perturbated near the excavation.

REVIEWER: James F. Thompson

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DATE: 06/21/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 202 CHAPTER NO.: 8

SEC. NO.: 8.4.2 PAGE. NO.: 209 FIG./TABL: 8.4.2.39

COMMENT

With respect to the two-drift-standoff, this figure illustrates the potential for problems if it is discovered that the blast damaged zone is more extensive than anticipated. It is stated that the design has allowed for flexibility in the test position, orientation, etc.; however, it is apparent that insufficient area will exist at the main test level should the disturbed zone extend farther than currently planned (as previously estimated).

REVIEWER: James F. Thompson

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DATE: 06/21/89

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TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 203 CHAPTER NO.: 8

SEC. NO.: 8.4.2 PAGE. NO.: 210 FIG./TABL:

COMMENT

It is evident that the Heated Block Test and the Canister Scale Heater Test will have thermal (and perhaps stress altered) zones of influence that overlap. Of concern is the resultant representativeness of data obtained from these experiments as a result of their close proximity to each other.

REVIEWER: James F. Thompson

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DATE: 06/21/89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 204 CHAPTER NO.: 8

SEC. NO.: 8.4.2.1.3.2 PAGE. NO.: 17 FIG./TABL:

COMMENT

The effect of the proposed excavation process and rock mass exposure to the atmospheric conditions will in fact alter the in situ ambient conditions and may extend beyond the hypothesized local zone of disturbance or alteration. The impact of such possibilities on the large-scale hydrologic, thermal, and mechanical in situ conditions needs to be accounted for.

REVIEWER: Nahel F. Kabazi

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DATE: 06-16-89

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TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 205 CHAPTER NO.: 8

SEC. NO.: 8.4.2.1.6.1 PAGE. NO.: 35 FIG./TABL:

COMMENT

If a possibility exists, as is the case here, for conducting in situ test in the Calico Hills nonwelded unit, then the need to address this issue at this stage of site characterization is present.

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DATE: 06-16-89

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TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 206 CHAPTER NO.: 8

SEC. NO.: 8.4.2.2.2.2 PAGE. NO.: 64 FIG./TABL:

COMMENT

Rewording or rework of this statement concerning the location of the unsaturated-zone, multipurpose, and systematic drilling program boreholes is needed. An ambiguity exists here as to location of the boreholes where one of the interpretation would be a requirement to place the drill holes as close to the minimum separation from the nearest drift as practicable.

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DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 207 CHAPTER NO.: 8

SEC. NO.: 8.4.2.2.2.2 PAGE. NO.: 75 FIG./TABL:

COMMENT

An attempt to define the drilling method for the Systematic Drilling Program should be made. An understanding of the magnitude of hydrologic and hydrochemical disturbance introduced by the technologically available drilling options needs to be developed.

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DATE: 06-16-89

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TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 208 CHAPTER NO.: 8

SEC. NO.: 8.4.2.3.1 PAGE. NO.: 144 FIG./TABL:

COMMENT

Air borehole drilling for the purpose of minimizing changes in the ambient moisture conditions during the characterization process needs further addressing. Bound limits for the change of ambient conditions need to be defined such that the relative allowable changes expected are delineated and the limiting boundary values that render the data "scientifically acceptable" are clearly developed.

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DATE: 06-16-89

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TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 209 CHAPTER NO.: 8

SEC. NO.: 8.4.2.3.1 PAGE. NO.: 145 FIG./TABL:

COMMENT

Penetration of air and water into the surrounding rock regions of the faults' hydrological characterization cannot be based on assumption which in turn are based on expectations. An analytically based simulation model is deemed appropriate for such characterization of fault zone permeability.

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DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 210 CHAPTER NO.: 8

SEC. NO.: 8.4.2.3.3.3 PAGE. NO.: 167 FIG./TABL:

COMMENT

An accurate representation of the schematic cross section drawing of the exploratory shafts 1 and 2 needs to reflect the total sinking depth in relative terms consistent with stated numerical values.

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 211 CHAPTER NO.: 8

SEC. NO.: 8.4.2.3.3.3 PAGE. NO.: 169 FIG./TABL:

COMMENT

A statement concerning the confidence in the Hydraulic isolation characteristics associated with the operational consideration in the development of the general arrangement of the Exploratory Shafts is prudent at this stage, since it can't be conclusively demonstrated.

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ORGANIZATION: Thompson Eng.

DATE: 06-16-89

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TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 212 CHAPTER NO.: 8

SEC. NO.: 8.4.2.3.6.1 PAGE. NO.: 205 FIG./TABL:

COMMENT

An outright discount of the effects of the discontinuous nature of jointed rock could prove critical to the overall performance of the ESF. It is crucial that an effort, on the part of the people involved in conducting the structural analysis calculations to support the design of the ESF underground excavations, be made to account for such a phenomenon.

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DATE: 06-16-89

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 213 CHAPTER NO.: 8

SEC. NO.: 8.4.2.3.6.1 PAGE. NO.: 207 FIG./TABL:

COMMENT

In stating that "From this testing, the fractures were found to be tighter after excavation than before," the statement seems somewhat ambiguous as to the conclusion to be drawn. Also, it is difficult to understand how the aperture of fractures became tighter after excavation but still the hydraulic quotient exhibited a characteristic increase in magnitude.

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DATE: 06-16-89

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TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 214 CHAPTER NO.: 8

SEC. NO.: 8.4.2.3.6.3 PAGE. NO.: 216 FIG./TABL:

COMMENT

The fact that a detailed description of the ESF in Chapter 6 evaluations does not rectify the statement made in this section. Up to this point the reader is left with the impression that the proposed ES1 and ES2 have different dimensions. There should have been a effort on the part of the responsible parties involved with this project to bring this discrepancy up much earlier, and possibly go as far as rewriting the pertinent section concerning the dimensions of ES-2.

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DATE: 06-16-89

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TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 215 CHAPTER NO.: 8

SEC. NO.: 8.4.3 PAGE. NO.: 34 FIG./TABL:

COMMENT

A more precise definition of the term "to the extent practical" needs to be given. With the way the design is being carried out at this stage, given the constant revision, modification, and preliminary nature of the repository layout, it is evident that a more accurate coordination of the proposed drillholes' locations with respect to the general repository's layout needs to be conducted.

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DATE: 06-16-89

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DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 216 CHAPTER NO.: 8

SEC. NO.: 8.4.3.2.1.2 PAGE. NO.: 15 FIG./TABL:

COMMENT

The extent of water-polymer mixture migration experienced during the drilling of USW G-1 needs to be determined. Also, the effect of the migratory pattern of this water-polymer mixture on the Site Characterization activities needs to be addressed.

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DATE: 06-16-89

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TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 217 CHAPTER NO.: 8

SEC. NO.: 8.4.3.2.1.4 PAGE. NO.: 19 FIG./TABL:

COMMENT

An accurate delineation of the phenomenon of water-vapor flow in an open borehole needs to be addressed. Presumptive conclusions as to the magnitude of the air flow are inadequate. A more detailed treatment of the nature of the excess air flows and the driving mechanisms are needed at this juncture.

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DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 218 CHAPTER NO.: 8

SEC. NO.: 8.4.3.2.3.1 PAGE. NO.: 29 FIG./TABL:

COMMENT

A definitive statement is more appropriate concerning the possibility of localized failure for the vertical emplacement drifts. Stating that the crown rock could be stabilized with ground support shows the inadequacy of the design thought, especially knowing that the ground support system itself is in the characterization design stage and has not been finalized.

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DOCUMENT TITLE: SCP
DOCUMENT NO.: DOE/RW-0199 AUTHOR: DOE

COMMENT NO.: 219 CHAPTER NO.: 8

SEC. NO.: 8.4.3.2.3.2 PAGE. NO.: 32 FIG./TABL:

COMMENT

This section addresses the analyses conducted in support of the excavation investigation and the effects of shaft convergence, demonstration breakout rooms, and sequential drift mining. It goes on to mention that "at the time of analysis, only one access drift was planned,....." without reference to any further analytical investigations planned to rectify their outright conclusion that the analysis carried out for one access drift is representative of that for three. It is critical that an analysis be carried out reflecting the more current proposal of three drifts.

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DATE: 06-16-89